The Ciao Prolog System

A Next Generation Logic Programming Environment
REFERENCE MANUAL
The Ciao System Documentation Series

Version 1.8

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Summary

Ciao is a *public domain, next generation* multi-paradigm programming environment with a unique set of features:

- Ciao offers a complete Prolog system, supporting *ISO-Prolog*, but its novel modular design allows both *restricting* and *extending* the language. As a result, it allows working with *fully declarative subsets* of Prolog and also to *extend* these subsets (or ISO-Prolog) both syntactically and semantically. Most importantly, these restrictions and extensions can be activated separately on each program module so that several extensions can coexist in the same application for different modules.
- Ciao also supports (through such extensions) programming with functions, higher-order (with predicate abstractions), constraints, and objects, as well as feature terms (records), persistence, several control rules (breadth-first search, iterative deepening, ...), concurrency (threads/engines), a good base for distributed execution (agents), and parallel execution. Libraries also support WWW programming, sockets, external interfaces (C, Java, TclTk, relational databases, etc.), etc.
- **Ciao** offers support for *programming in the large* with a robust module/object system, module-based separate/incremental compilation (automatically –no need for makefiles), an assertion language for declaring (*optional*) program properties (including types and modes, but also determinacy, non-failure, cost, etc.), automatic static inference and static/dynamic checking of such assertions, etc.
- **Ciao** also offers support for *programming in the small* producing small executables (including only those builtins used by the program) and support for writing scripts in Prolog.
- The **Ciao** programming environment includes a classical top-level and a rich emacs interface with an embeddable source-level debugger and a number of execution visualization tools.
- The **Ciao** compiler (which can be run outside the top level shell) generates several forms of architecture-independent and stand-alone executables, which run with speed, efficiency and executable size which are very competive with other commercial and academic Prolog/CLP systems. Library modules can be compiled into compact bytecode or C source files, and linked statically, dynamically, or autoloaded.
- The novel modular design of Ciao enables, in addition to modular program development, effective global program analysis and static debugging and optimization via source to source program transformation. These tasks are performed by the **Ciao preprocessor** (`ciaopp`, distributed separately).
- The **Ciao** programming environment also includes `lpdoc`, an automatic documentation generator for LP/CLP programs. It processes Prolog files adorned with (**Ciao**) assertions and machine-readable comments and generates manuals in many formats including `postscript`, `pdf`, `texinfo`, `info`, `HTML`, `man`, etc. , as well as on-line help, ascii `README` files, entries for indices of manuals (`info`, WWW, ...), and maintains WWW distribution sites.

Ciao is distributed under the GNU General Public License.

1 Introduction

1.1 About this manual

This is the *Reference Manual* for the Ciao Prolog development system. It contains basic information on how to install Ciao Prolog and how to write, debug, and run Ciao Prolog programs from the command line, from inside GNU `emacs`, or from a windowing desktop. It also documents all the libraries available in the standard distribution.

This manual has been generated using the *LPdoc* semi-automatic documentation generator for LP/CLP programs [HC97,Her00]. `lpdoc` processes Prolog files (and files in other CLP languages) adorned with assertions and machine-readable comments, which should be written in the Ciao assertion language [PBH97,PBH00]. From these, it generates manuals in many formats including `postscript`, `pdf`, `texinfo`, `info`, `HTML`, `man`, etc., as well as on-line help, ascii `README` files, entries for indices of manuals (`info`, WWW, ...), and maintains WWW distribution sites.

The big advantage of this approach is that it is easier to keep the on-line and printed documentation in sync with the source code [Knu84]. As a result, *this manual changes continually as the source code is modified.* Because of this, the manual has a version number. You should make sure the manual you are reading, whether it be printed or on-line, coincides with the version of the software that you are using.

The approach also implies that there is often a variability in the degree to which different libraries or system components are documented. Many libraries offer abundant documentation, but a few will offer little. The latter is due to the fact that we tend to include libraries in the manual if the code is found to be useful, even if they may still contain sparse documentation. This is because including a library in the manual will at the bare minimum provide formal information (such as the names of exported predicates and their arity, which other modules it loads, etc.), create index entries, pointers for on-line help in the electronic versions of the manuals, and command-line completion capabilities inside `emacs`. Again, the manual is being updated continuously as the different libraries (and machine-readable documentation in them) are improved.

1.2 About the Ciao Prolog development system

The Ciao system is a full programming environment for developing programs in the Prolog language and in several other languages which are extensions and modifications of Prolog in several interesting and useful directions. The programming environment offers a number of tools such as the Ciao standalone compiler (`ciaoc`), a traditional-style top-level interactive shell (`ciaosh` or `ciao`), an interpreter of scripts written in Prolog (`ciao-shell`), a Prolog `emacs` mode (which greatly helps the task of developing programs with support for editing, debugging, version/change tracking, etc.), numerous libraries, a powerful program preprocessor (`ciaopp` [BdlBH99,BLGPH99,HBPLG99], which supports static debugging and optimization from program analysis via source to source program transformation), and an automatic documentation generator (`lpdoc`) [HC97,Her00]. A number of execution visualization tools [CGH93,CH00d,CH00c] are also available.

This manual documents the first four of the tools mentioned above [see PART I - The program development environment], and the Ciao Prolog language and libraries. The `ciaopp` and `lpdoc` tools are documented in separate manuals.

The Ciao language [see PART II - The Ciao basic language (engine)] has been designed from the ground up to be small, but to also allow extensions and restrictions in a modular way. The first objective allows producing small executables (including only those builtins used by the program), providing basic support for pure logic programming, and being able to write

scripts in Prolog. The second one allows supporting standard ISO-Prolog [see PART III - ISO-Prolog library (iso)], as well as powerful extensions such as constraint logic programming, functional logic programming, and object-oriented logic programming [see PART VII - Ciao Prolog extensions], and restrictions such as working with pure horn clauses.

The design of Ciao has also focused on allowing modular program development, as well as automatic program manipulation and optimization. Ciao includes a robust module system [CH00a], module-based automatic incremental compilation [CH99], and modular global program analysis, debugging and optimization [PH99], based on a rich assertion language [see PART V - Annotated Prolog library (assertions)] for declaring (optional) program properties (including types and modes), which can be checked either statically or dynamically. The program analysis, static debugging and optimization tasks related to these assertions are performed by the `ciaopp` preprocessor, as mentioned above. These assertions (together with special comment-style declarations) are also the ones used by the `lpdoc` autodocumenter to generate documentation for programs (the comment-style declarations are documented in the `lpdoc` manual).

Ciao also includes several other features and utilities, such as support for several forms of executables, concurrency (threads), distributed and parallel execution, higher-order, WWW programming (PiLLoW [CHV96b]), interfaces to other languages like C and Java, database interfaces, graphical interfaces, etc., etc. [see PARTS VI to XI].

1.3 ISO-Prolog compliance versus extensibility

One of the innovative features of Ciao is that it has been designed to subsume *ISO-Prolog* (International Standard ISO/IEC 13211-1, PROLOG: Part 1–General Core [DEDC96]), while at the same time extending it in many important ways. The intention is to ensure that all ISO-compliant Prolog programs run correctly under Ciao. At the same time, the Ciao module system (see [PART II - The Ciao basic language (engine)] and [CH00a] for a discussion of the motivations behind the design) allows selectively avoiding the loading of most ISO-builtins (and changing some other ISO characteristics) when not needed, so that it is possible to work with purer subsets of Prolog and also to build small executables. Also, this module system makes it possible to develop extensions using these purer subsets (or even the full ISO-standard) as a starting point. Using these features, the Ciao distribution includes libraries which significantly extend the language both syntactically and semantically.

Compliance with ISO is still not complete: currently there are some minor deviations in, e.g., the treatment of characters, the syntax, some of the arithmetic functions, and part of the error system. On the other hand, Ciao has been reported by independent sources (members of the standarization body) to be one of the most conforming Prologs at the moment of this writing, and the first one to be able to compile all the standard-conforming test cases. Also, Ciao does not offer a strictly conforming mode which rejects uses of non-ISO features. However, in order to aid programmers who wish to write standard compliant programs, library predicates that correspond to those in the ISO-Prolog standard are marked specially in the manuals, and differences between the Ciao and the prescribed ISO-Prolog behaviours, if any, are commented appropriately.

The intention of the Ciao developers is to progressively complete the compliance of Ciao with the published parts of the ISO standard as well as with other reasonable extensions of the standard may be published in the future. However, since one of the design objectives of Ciao is to address some shortcomings of previous implementations of Prolog and logic programming in general, we also hope that some of the better ideas present in the system will make it eventually into the standards.

1.4 About the name of the System

After reading the previous sections the sharp reader may have already seen the logic behind the 'Ciao Prolog' name. Ciao is an interesting word which means both *hello* and *goodbye*. Ciao

Prolog intends to be a really good, all-round, freely available ISO-Prolog system which can be used as a classical Prolog, in both academic and industrial environments (and, in particular, to introduce users to Prolog and to constraint and logic programming –the *hello* part). But Ciao is also a new-generation, multiparadigm programming language and program development system which goes well beyond Prolog and other classical logic programming languages. And it has the advantage (when compared to other systems) that it does so while keeping full Prolog compatibility when needed.

1.5 Referring to Ciao

If you find Ciao or any of its components useful, we would appreciate very much if you added a reference to this manual (i.e., the Ciao reference manual [BCC97]) in your work. The following is an appropriate BiBTeX entry with the relevant data:

```
@techreport{ciao-reference-manual-tr,
  author =       {F. Bueno and D. Cabeza and M. Carro and M. Hermenegildo
                  and P. L\'{o}pez-Garc\'{\i}a and G. Puebla},
  title =        {The Ciao Prolog system. Reference manual},
  institution =  {School of Computer Science,
                  Technical University of Madrid (UPM)},
  year =         1997,
  month =        {August},
  number =       {{CLIP}3/97.1},
  note =         {Available from http://www.clip.dia.fi.upm.es/}
}
```

1.6 Syntax terminology and notational conventions

This manual is not meant to be an introduction to the Prolog language. The reader is referred to standard textbooks on Prolog such as [SS86,CM81,Apt97,Hog84]. However, we would like to refresh herein some concepts for the sake of establishing terminology. Also, we will briefly introduce a few of the extensions that Ciao brings to the Prolog language.

1.6.1 Predicates and their components

In Prolog, procedures are called *predicates* and predicate calls *literals*. They all have the classical syntax of procedures (and of logic predications and of mathematical functions). Predicates are identified in this manual by a keyword 'PREDICATE' at the right margin of the place where they are documented.

Prolog instructions are expressions made up of control constructs (Chapter 13 [Control constructs/predicates], page 87) and literals, and are called *goals*. Literals are also (atomic) goals.

A predicate definition is a sequence of clauses. A clause has the form "`H :- B.`" (ending in '.'), where `H` is syntactically the same as a literal and is called the clause *head*, and `B` is a goal and is called the clause *body*. A clause with no body is written "`H.`" and is called a *fact*. Clauses with body are also called *rules*. A Prolog program is a sequence of predicate definitions.

1.6.2 Characters and character strings

We adopt the following convention for delineating character strings in the text of this manual: when a string is being used as a Prolog atom it is written thus: `user` or `'user'`; but in all other circumstances double quotes are used (as in `"hello"`).

When referring to keyboard characters, printing characters are written thus: ⟨a⟩, while control characters are written like this: ⟨^A⟩. Thus ⟨^C⟩ is the character you get by holding down the ⟨CTL⟩ key while you type ⟨c⟩. Finally, the special control characters carriage-return, line-feed and space are often abbreviated to ⟨RET⟩, ⟨LFD⟩ and ⟨SPC⟩ respectively.

1.6.3 Predicate specs

Predicates in Prolog are distinguished by their name *and* their arity. We will call `name/arity` a *predicate spec*. The notation `name/arity` is therefore used when it is necessary to refer to a predicate unambiguously. For example, `concatenate/3` specifies the predicate which is named "concatenate" and which takes 3 arguments.

(Note that different predicates may have the same name and different arity. Conversely, of course, they may have the same arity and different name.)

1.6.4 Modes

When documenting a predicate, we will often describe its usage with a mode spec which has the form `name(Arg1, ..., ArgN)` where each `Arg` may be preceded by a *mode*. A mode is a functor which is wrapped around an argument (or prepended if defined as an operator). Such a mode allows documenting in a compact way the instantiation state on call and exit of the argument to which it is applied. The set of modes which can be used in Ciao is not fixed. Instead, arbitrary modes can be defined by in programs using the `modedef/1` declarations of the Ciao *assertion language* (Chapter 52 [The Ciao assertion package], page 227 for details). Modes are identified in this manual by a keyword 'MODE'.

Herein, we will use the set of modes defined in the Ciao `isomodes` library, which is essentially the same as those used in the ISO-Prolog standard (Chapter 57 [ISO-Prolog modes], page 253).

1.6.5 Properties and types

Although Ciao Prolog is *not* a typed language, it allows writing (and using) types, as well as (more general) properties. There may be properties of the states and of the computation. Properties of the states allow expressing characteristics of the program variables during computation, like in `sorted(X)` (`X` is a sorted list). Properties of the computation allow expressing characteristics of a whole computation, like in `is_det(p(X,Y))` (such calls yield only one solution). Properties are just a special form of predicates (Chapter 54 [Declaring regular types], page 241) and are identified in this manual by a keyword 'PROPERTY'.

Ciao types are *regular types* (Chapter 54 [Declaring regular types], page 241), which are a special form of properties themselves. They are identified in this manual by a keyword 'REGTYPE'.

1.6.6 Declarations

A *declaration* provides information to one of the Ciao environment tools. Declarations are interspersed in the code of a program. Usually the target tool is either the compiler (telling it that a predicate is dynamic, or a meta-predicate, etc.), the preprocessor (which understands declarations of properties and types, assertions, etc.), or the autodocumenter (which understands the previous declarations and also certain "comment" declarations).

A declaration has the form `:- D.` where `D` is syntactically the same as a literal. Declarations are identified in this manual by a keyword 'DECLARATION'.

In Ciao users can define (and document) new declarations. New declarations are typically useful when defining extensions to the language (which in Ciao are called packages). Such extensions are often implemented as expansions (see Chapter 26 [Extending the syntax], page 145).

There are many such extensions in Ciao. The `functions` library, which provides fuctional syntax, is an example. The fact that in Ciao expansions are local to modules (as operators, see below) makes it possible to use a certain language extension in one module without affecting other modules.

1.6.7 Operators

An *operator* is a functor (or predicate name) which has been declared as such, thus allowing its use in a prefix, infix, or suffix fashion, instead of the standard procedure-like fashion. E.g., declaring `+` as an infix operator allows writing `X+Y` instead of `'+'(X,Y)` (which may still, of course, be written).

Operators in Ciao are local to the module/file where they are declared. However, some operators are standard and allowed in every program (see Chapter 35 [Defining operators], page 181). This manual documents the operator declarations in each (library) module where they are included. As with expansions, the fact that in Ciao operators are local to modules makes it possible to use a certain language extension in one module without affecting other modules.

1.7 A tour of the manual

The rest of the introductory chapters after this one provide a first "getting started" introduction for newcomers to the Ciao system. The rest of the chapters in the manual are organized into a sequence of major parts as follows:

1.7.1 PART I - The program development environment

This part documents the components of the basic Ciao program development environment. They include:

ciaoc: the standalone compiler, which creates executables without having to enter the interactive top-level.

ciaosh: (also invoked simply as `ciao`) is an interactive top-level shell, similar to the one found on most Prolog systems (with some enhancements).

debugger.pl:
a Byrd box-type debugger, similar to the one found on most Prolog systems (also with some enhancements, such as source-level debugging). This is not a standalone application, but is rather included in `ciaosh`, as is done in other Prolog systems. However, it is also *embeddable*, in the sense that it can be included as a library in executables, and activated dynamically and conditionally while such executables are running.

ciao-shell: an interpreter/compiler for *Prolog scripts* (i.e., files containing Prolog code which run without needing explicit compilation).

ciao.el: a *complete program development enviroment*, based on GNU emacs, with syntax coloring, direct access to all the tools described above (as well as the preprocessor and the documenter), atomatic location of errors, source-level debugging, context-sensitive access to on-line help/manuals, etc. The use of this environment is *very highly recommended*!

The Ciao program development environment also includes `ciaopp`, the preprocessor, and `lpdoc`, the documentation generator, which are described in separate manuals.

1.7.2 PART II - The Ciao basic language (engine)

This part documents the *Ciao basic builtins*. These predefined predicates and declarations are available in every program, unless the `pure` package is used (by using a `:- module(_,_,[pure]).` declaration or `:- use_package(pure).`). These predicates are contained in the `engine` directory within the `lib` library. The rest of the library predicates, including the packages that provide most of the ISO-Prolog builtins, are documented in subsequent parts.

1.7.3 PART III - ISO-Prolog library (iso)

This part documents the *iso* package which provides to Ciao programs (most of) the ISO-Prolog functionality , including the *ISO-Prolog builtins* not covered by the basic library. All these predicates are loaded by default in user files and in modules which use standard module declarations such as:

`:- module(`*modulename*`,`*exports*`).`

which are equivalent to:

`:- module(`*modulename*`,`*exports*`,[iso]).`

or

`:- module(`*modulename*`,`*exports*`).`

`:- use_package([iso]).`

If you do not want these ISO builtins loaded for a given file (in order to make the executable smaller) you can ask for this explicitly using:

`:- module(`*modulename*`,`*exports*`,[]).`

or

`:- module(`*modulename*`,`*exports*`).`

`:- use_package([]).`

See the description of the declarations for declaring modules and using other modules, and the documentation of the `iso` library for details.

1.7.4 PART IV - Classic Prolog library (classic)

This part documents some Ciao libraries which provide additional predicates and functionalities that, despite not being in the ISO standard, are present in many popular Prolog systems. This includes definite clause grammars (DCGs), "Quintus-style" internal database, list processing predicates, dictionaries, string processing, DEC-10 Prolog-style input/output, formatted output, dynamic loading of modules, activation of operators at run-time, etc.

1.7.5 PART V - Annotated Prolog library (assertions)

Ciao allows *annotating* the program code with *assertions*. Such assertions include type and instantiation mode declarations, but also more general properties as well as comments in the style of the *literate programming*. These assertions document predicates (and modules and whole applications) and can be used by the Ciao preprocessor/compiler while debugging and optimizing the program or library, and by the Ciao documenter to build the program or library reference manual.

1.7.6 PART VI - Ciao Prolog library miscellanea

This part documents several Ciao libraries which provide different useful additional functionalities. Such functionalities include performing operating system calls, gathering statistics from the Prolog engine, file and file name manipulation, error and exception handling, fast reading and writing of terms (marshalling and unmarshalling), file locking, program reporting messages, pretty-printing programs and assertions, a browser of the system libraries, additional expansion utilities, concurrent aggregates, graph visualization, etc.

1.7.7 PART VII - Ciao Prolog extensions

The libraries documented in this part extend the Ciao language in several different ways. The extensions include:

- pure Prolog programming (well, this can be viewed more as a restriction than an extension);
- feature terms or *records* (i.e., structures with names for each field);
- parallel programming (e.g., &-Prolog style);
- functional syntax;
- higher-order library;
- global variables;
- `setarg` and `undo`;
- delaying predicate execution;
- active modules;
- breadth-first execution;
- iterative deepening-based execution;
- constraint logic programming;
- object oriented programming.

1.7.8 PART VIII - Interfaces to other languages and systems

The following interfaces to/from Ciao Prolog are documented in this part:

- External interface (e.g., to C).
- Socket interface.
- Tcl/tk interface.
- Web interface (http, html, xml, etc.);
- Persistent predicate databases (interface between the Prolog internal database and the external file system).
- SQL-like database interface (interface between the Prolog internal database and external SQL/ODBC systems).
- Java interface.
- Calling emacs from Prolog.

1.7.9 PART IX - Abstract data types

This part includes libraries which implement some generic data structures (abstract data types) that are used frequently in programs or in the Ciao system itself.

1.7.10 PART X - Miscellaneous standalone utilities

This is the documentation for a set of miscellaneous standalone utilities contained in the `etc` directory of the Ciao distribution.

1.7.11 PART XI - Contributed libraries

This part includes a number of libraries which have contributed by users of the Ciao system. Over time, some of these libraries are moved to the main library directories of the system.

1.7.12 PART XII - Appendices

These appendices describe the installation of the Ciao environment on different systems and some other issues such as reporting bugs, signing up on the Ciao user's mailing list, downloading new versions, limitations, etc.

If you feel you have contributed to the development of Ciao and we have forgotten adding your name to this list or the acknowledgements given in the different chapters, please let us know and we will be glad to give proper credits.

1.9 Version/Change Log (ciao)

Version 1.8 (2002/5/16, 21:20:27 CEST)

- Improvements related to supported platforms:
  - Support for Mac OS X 10.1, based on the Darwin kernel.
  - Initial support for compilation on Linux for Power PC (contributed by *Paulo Moura*).
  - Workaround for incorrect C compilation while using newer (> 2.95) gcc compilers.
  - .bat files generated in Windows.
- Changes in compiler behavior and user interface:
  - Corrected a bug which caused wrong code generation in some cases.
  - Changed execution of initialization directives. Now the initialization of a module/file never runs before the initializations of the modules from which the module/file imports (excluding circular dependences).
  - The engine is more intelligent when looking for an engine to execute bytecode; this caters for a variety of situations when setting explicitly the CIAOLIB environment variable.
  - Fixed bugs in the toplevel: behaviour of `module:main` calls and initialization of a module (now happens after related modules are loaded).
  - Layout char not needed any more to end Prolog files.
  - Syntax errors now disable .itf creation, so that they show next time the code is used without change.
  - Redefinition warnings now issued only when an unqualified call is seen.
  - Context menu in Windows can now load a file into the toplevel.
  - Updated Windows installation in order to run CGI executables under Windows: a new information item is added to the registry.
  - Added new directories found in recent Linux distributions to INFOPATH.
  - Emacs-based environment and debugger improved:
    - Errors located immediataly after code loading.
    - Improved ciao-check-types-modes (preprocessor progress now visible).
    - Fixed loading regions repeatedly (no more predicate redefinition warnings).
    - Added entries in `ciaopp` menu to set verbosity of output.
    - Fixed some additional xemacs compatibility issues (related to searches).
    - Errors reported by inferior processes are now explored in forward order (i.e., the first error rewported is the first one highlighted). Improved tracking of errors.
    - Specific tool bar now available, with icons for main fuctions (works from emacs 21.1 on). Also, other minor adaptations for working with emacs 21.1 and later.
    - Debugger faces are now locally defined (and better customization). This also improves comtability with xemacs (which has different faces).

        - Direct access to a common use of the preprocessor (checking modes/types and locating errors) from toolbar.
        - Inferior modes for Ciao and CiaoPP improved: contextual help turned on by default.
        - Fixes to set-query. Also, previous query now appears in prompt.
        - Improved behaviour of stored query.
        - Improved behaviour of recentering, finding errors, etc.
        - Wait for prompt has better termination characteristics.
        - Added new interactive entry points (M-x): ciao, prolog, ciaopp.
        - Better tracking of last inferior buffer used.
        - Miscellanous bugs removed; some colors changed to adapt to different Emacs versions.
        - Fixed some remaining incompatibilities with xemacs.
        - `:- doc` now also supported and highlighted.
        - Eliminated need for calendar.el
        - Added some missing library directives to fontlock list, organized this better.
- New libraries added to the system:
    - hiord: new library which needs to be loaded in order to use higher-order call/N and P(X) syntax. Improved model for predicate abstractions.
    - fuzzy: allows representing fuzzy information in the form or Prolog rules.
    - use_url: allows loading a module remotely by using a WWW address of the module source code
    - andorra: alternative search method where goals which become deterministic at run time are executed before others.
    - iterative deepening (id): alternative search method which makes a depth-first search until a predetermined depth is reached. Complete but in general cheaper than breadth first.
    - det_hook: allows making actions when a deterministic situation is reached.
    - ProVRML: read VRML code and translate it into Prolog terms, and the other way around.
    - io_alias_redirection: change where stdin/stdout/stderr point to from within Ciao Prolog programs.
    - tcl_tk: an interface to Tcl/Tk programs.
    - tcl_tk_obj: object-based interface to Tcl/Tk graphical objects.
    - CiaoPP: options to interface with the CiaoPP Prolog preprocessor.
- Some libraries greatly improved:
    - WebDB: utilities to create WWW-based database interfaces.
    - Improved java interface implementation (this forced renaming some interface primitives).
    - User-transparent persistent predicate database revamped:
        - Implemented passerta_fact/1 (asserta_fact/1).
        - Now it is never necessary to explicitly call init_persdb, a call to initialize_db is only needed after dynamically defining facts of persistent_dir/2. Thus, pcurrent_fact/1 predicate eliminated.

        - Facts of persistent predicates included in the program code are now included in the persistent database when it is created. They are ignored in successive executions.
        - Files where persistent predicates reside are now created inside a directory named as the module where the persistent predicates are defined, and are named as F_A* for predicate F/A.
        - Now there are two packages: persdb and 'persdb/ll' (for low level). In the first, the standard builtins asserta_fact/1, assertz_fact/1, and retract_fact/1 are replaced by new versions which handle persistent data predicates, behaving as usual for normal data predicates. In the second package, predicates with names starting with 'p' are defined, so that there is not overhead in calling the standard builtins.
        - Needed declarations for persistent_dir/2 are now included in the packages.
    - SQL now works with mysql.
    - system: expanded to contain more predicates which act as interface to the underlying system / operating system.
- Other libraries improved:
    - xref: creates cross-references among Prolog files.
    - concurrency: new predicates to create new concurrent predicates on-the-fly.
    - sockets: bugs corrected.
    - objects: concurrent facts now properly recognized.
    - fast read/write: bugs corrected.
    - Added 'webbased' protocol for active modules: publication of active module address can now be made through WWW.
    - Predicates in library(dynmods) moved to library(compiler).
    - Expansion and meta predicates improved.
    - Pretty printing.
    - Assertion processing.
    - Module-qualified function calls expansion improved.
    - Module expansion calls goal expansion even at runtime.
- Updates to builtins (there are a few more; these are the most relevant):
    - Added a prolog_flag to retrieve the version and patch.
    - current_predicate/1 in library(dynamic) now enumerates non-engine modules, prolog_sys:current_predicate/2 no longer exists.
    - exec/* bug fixed.
    - srandom/1 bug fixed.
- Updates for C interface:
    - Fixed bugs in already existing code.
    - Added support for creation and traversing of Prolog data structures from C predicates.
    - Added support for raising Prolog exceptions from C predicates.
    - Preliminary support for calling Prolog from C.
- Miscellaneous updates:
    - Installation made more robust.
    - Some pending documentation added.

- 'ciao' script now adds (locally) to path the place where it has been installed, so that other programs can be located without being explicitly in the $PATH.
- Loading programs is somewhat faster now.
- Some improvement in printing path names in Windows.

Version 1.7 (2000/7/12, 19:1:20 CEST)
Development version following even 1.6 distribution.

Version 1.6 (2000/7/12, 18:55:50 CEST)
- Source-level debugger in emacs, breakpts.
- Emacs environment improved, added menus for Ciaopp and LPDoc.
- Debugger embeddable in executables.
- Stand-alone executables available for UNIX-like operating systems.
- Many improvements to emacs interface.
- Menu-based interface to autodocumenter.
- Threads now available in Win32.
- Many improvements to threads.
- Modular clp(R) / clp(Q).
- Libraries implementing And-fair breadth-first and iterative deepening included.
- Improved syntax for predicate abstractions.
- Library of higher-order list predicates.
- Better code expansion facilities (macros).
- New delay predicates (when/2).
- Compressed object code/executables on demand.
- The size of atoms is now unbound.
- Fast creation of new unique atoms.
- Number of clauses/predicates essentially unbound.
- Delayed goals with freeze restored.
- Faster compilation and startup.
- Much faster fast write/read.
- Improved documentation.
- Other new libraries.
- Improved installation/deinstallation on all platforms.
- Many improvements to autodocumenter.
- Many bug fixes in libraries and engine.

Version 1.5 (1999/11/29, 16:16:23 MEST)
Development version following even 1.4 distribution.

Version 1.4 (1999/11/27, 19:0:0 MEST)
- Documentation greatly improved.
- Automatic (re)compilation of foreign files.
- Concurrency primitives revamped; restored &Prolog-like multiengine capability.
- Windows installation and overall operation greatly improved.
- New version of O'Ciao class/object library, with improved performance.
- Added support for "predicate abstractions" in call/N.
- Implemented reexportation through reexport declarations.

- Changed precedence of importations, last one is now higher.
- Modules can now implicitly export all predicates.
- Many minor bugs fixed.

Version 1.3 (1999/6/16, 17:5:58 MEST)
Development version following even 1.2 distribution.

Version 1.2 (1999/6/14, 16:54:55 MEST)
Temporary version distributed locally for extensive testing of reexportation and other 1.3 features.

Version 1.1 (1999/6/4, 13:30:37 MEST)
Development version following even 1.0 distribution.

Version 1.0 (1999/6/4, 13:27:42 MEST)
- Added Tcl/Tk interface library to distribution.
- Added push_prolog_flag/2 and pop_prolog_flag/1 declarations/builtins.
- Filename processing in Windows improved.
- Added redefining/1 declaration to avoid redefining warnings.
- Changed syntax/1 declaration to use_package/1.
- Added add_clause_trans/1 declaration.
- Changed format of .itf files such that a '+' stands for all the standard imports from engine, which are included in c_itf source internally (from engine(builtin_exports)). Further changes in itf data handling, so that once an .itf file is read in a session, the file is cached and next time it is needed no access to the file system is required.
- Many bugs fixed.

Version 0.9 (1999/3/10, 17:3:49 CET)
- Test version before 1.0 release. Many bugs fixed.

Version 0.8 (1998/10/27, 13:12:36 MET)
- Changed compiler so that only one pass is done, eliminated `.dep` files.
- New concurrency primitives.
- Changed assertion comment operator to #.
- Implemented high-order with call/N.
- Integrated SQL-interface to external databases with persistent predicate concept.
- First implementation of object oriented programming package.
- Some bugs fixed.

Version 0.7 (1998/9/15, 12:12:33 MEST)
- Improved debugger capabilities and made easier to use.
- Simplified assertion format.
- New arithmetic functions added, which complete all ISO functions.
- Some bugs fixed.

Version 0.6 (1998/7/16, 21:12:7 MET DST)
- Defining other path aliases (in addition to 'library') which can be loaded dynamically in executables is now possible.
- Added the posibility to define multifile predicates in the shell.
- Added the posibility to define dynamic predicates dynamically.
- Added addmodule meta-argument type.

- Implemented persistent data predicates.
- New version of PiLLoW WWW library (XML, templates, etc.).
- Ported active modules from "distributed Ciao" (independent development version of Ciao).
- Implemented lazy loading in executables.
- Modularized engine(builtin).
- Some bugs fixed.

Version 0.5 (1998/3/23)

- First Windows version.
- Integrated debugger in toplevel.
- Implemented DCG's as (Ciao-style) expansions.
- Builtins renamed to match ISO-Prolog.
- Made ISO the default syntax/package.

Version 0.4 (1998/2/24)

- First version with the new Ciao emacs mode.
- Full integration of concurrent engine and compiler/library.
- Added new_declaration/1 directive.
- Added modular syntax enhancements.
- Shell script interpreter separated from toplevel shell.
- Added new compilation warnings.

Version 0.3 (1997/8/20)

- Ciao builtins modularized.
- New prolog flags can be defined by libraries.
- Standalone comand-line compiler available, with automatic "make".
- Added assertions and regular types.
- First version using the automatic documentation generator.

Version 0.2 (1997/4/16)

- First module system implemented.
- Implemented exceptions using catch/3 and throw/1.
- Added functional & record syntax.
- Added modular sentence, term, and goal translations.
- Implemented attributed variables.
- First CLPQ/CLPR implementation.
- Added the posibility of linking external .so files.
- Changes in syntax to allow `P(X)` and `"string"||L`.
- Changed to be more similar to ISO-Prolog.
- Implemented Prolog shell scripts.
- Implemented data predicates.

Version 0.1 (1997/2/13)

First fully integrated, standalone Ciao distribution. Based on integrating into an evolution of the &-Prolog engine/libraries/preprocessor [Her86,HG91] many functionalities from several previous independent development versions of Ciao [HC93,HC94,HCC95,Bue95,CLI95,HBdlBP95,HBC96,CHV96b,HBC99].

2 Getting started on Un*x-like machines

Author(s): M.Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#133 (2001/11/1, 16:34:6 CET)

This part guides you through some very basic first steps with Ciao on a Un*x-like system. It assumes that Ciao is already installed correctly on your Un*x system. If this is not the case, then follow the instructions in Chapter 200 [Installing Ciao from the source distribution], page 735 first.

We start with by describing the basics of using Ciao from a normal command shell such as `sh/bash`, `csh/tcsh`, etc. We strongly recommend reading also Section 2.4 [An introduction to the Ciao emacs environment (Un*x)], page 20 for the basics on using Ciao under `emacs`, which is a much simpler and much more powerful way of developing Ciao programs, and has the advantage of offering an almost identical environment under Un*x and Windows.

2.1 Testing your Ciao Un*x installation

It is a good idea to start by performing some tests to check that Ciao is installed correctly on your system (these are the same tests that you are instructed to do during installation, so you can obviously skip them if you have done them already at that time). If any of these tests do not succeed either your environment variables are not set properly (see Section 2.2 [Un*x user setup], page 17 for how to fix this):

- Typing `ciao` (or `ciaosh`) should start the typical Prolog top-level shell.
- In the top-level shell, Prolog library modules should load correctly. Type for example `use_module(library(dec10_io))` –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.
- Typing `ciaoc` should produce the help message from the Ciao standalone compiler.
- Typing `ciao-shell` should produce a message saying that no code was found. This is a Ciao application which can be used to write scripts written in Prolog, i.e., files which do not need any explicit compilation to be run.

Also, the following documentation-related actions should work:

- If the `info` program is installed, typing `info` should produce a list of manuals which *should include Ciao manual(s) in a separate area* (you may need to log out and back in so that your shell variables are reinitialized for this to work).
- Opening with a WWW browser (e.g., `netscape`) the directory or `URL` corresponding to the `DOCROOT` setting should show a series of Ciao-related manuals. Note that *style sheets* should be activated for correct formatting of the manual.
- Typing `man ciao` should produce a man page with some very basic general information on Ciao (and pointing to the on-line manuals).
- The `DOCROOT` directory should contain the manual also in the other formats such as `postscript` or `pdf` which specially useful for printing. See Section 2.3.7 [Printing manuals (Un*x)], page 20 for instructions.

2.2 Un*x user setup

If the tests above have succeeded, the system is probably installed correctly and your environment variables have been set already. In that case you can skip to the next section.

Otherwise, if you have not already done so, make the following modifications in your startup scripts, so that these files are used (`<LIBROOT>` must be replaced with the appropriate value, i.e., where the Ciao library is installed):

- For users a *csh-compatible shell* (`csh`, `tcsh`, ...), add to `~/.cshrc`:

```
if ( -e <LIBROOT>/ciao/DOTcshrc ) then
   source <LIBROOT>/ciao/DOTcshrc
endif
```

  `Mac OS X` users should add (or modify) the `path` file in the directory `~/Library/init/tcsh`, adding the lines shown above. **Note:** while this is recognized by the terminal shell, and therefore by the text-mode Emacs which comes with Mac OS X, the Aqua native Emacs 21 does not recognize that initialization. It is thus necessary, at this moment, to set manually the Ciao shell (ciaosh) and Ciao library location by hand. This can be done from the Ciao menu within Emacs after a Ciao Prolog file has been loaded. We suppose that the reason is that Mac OS X does not actually consult the per-user initialization files on startup. It should also be possible to put the right initializations in the .emacs file using the `setenv` function of Emacs-lisp, as in

```
(setenv "CIAOLIB" "<LIBROOT>/ciao")
```

  The same can be done for the rest of the variables initialized in `<LIBROOT>/ciao/DOTcshrc`

- For users of an *sh-compatible shell* (`sh`, `bash`, ...), add to `~/.profile`:

```
if [ -f <LIBROOT>/ciao/DOTprofile ]; then
   . <LIBROOT>/ciao/DOTprofile
fi
```

  This will set up things so that the Ciao executables are found and you can access the Ciao system manuals using the `info` command. Note that, depending on your shell, *you may have to log out and back in* for the changes to take effect.

- Also, if you use `emacs` (highly recommended) add this line to your `~/.emacs` file:

```
(load-file "<LIBROOT>/ciao/DOTemacs.el")
```

If after following these steps things do not work properly, then the installation was probably not completed properly and you may want to try reinstalling the system.

2.3 Using Ciao from a Un*x command shell

2.3.1 Starting/exiting the top-level shell (Un*x)

The basic methods for starting/exiting the top-level shell have been discussed above. If upon typing `ciao` you get a "command not found" error or you get a longer message from Ciao before starting, it means that either Ciao was not installed correctly or you environment variables are not set up properly. Follow the instructions on the message printed by Ciao or refer to the installation instructions regarding user-setup for details.

2.3.2 Getting help (Un*x)

The basic methods for accessing the manual on-line have also been discussed above. Use the table of contents and the indices of *predicates*, *libraries*, *concepts*, etc. to find what you are looking for. Context-sensitive help is available within the `emacs` environment (see below).

2.3.3 Compiling and running programs (Un*x)

Once the shell is started, you can compile and execute Prolog modules inside the interactive top-level shell in the standard way. E.g., type `use_module(`*file*`).`, `use_module(library(`*file*`)).` for library modules, `ensure_loaded(`*file*`).` for files which are not modules, and `use_package(`*file*`).` for library packages (these are syntactic/semantic packages that extend the Ciao

Prolog language in many different ways). Note that the use of `compile/1` and `consult/1` is discouraged in Ciao.

For example, you may want to type `use_package(iso)` to ensure Ciao has loaded all the ISO builtins (whether this is done by default or not depends on your `.ciaorc` file). Do not worry about any "module already in executable" messages –these are normal and simply mean that a certain module is already pre-loaded in the top-level shell. At this point, typing `write(hello).` should work.

Note that some predicates that may be built-ins in other Prologs are available through libraries in Ciao. This facilitates making small executables.

To change the working directory to, say, the `examples` directory in the Ciao root directory, first do:

```
?- use_module(library(system)).
```

(loading the `system` library makes a number of system-related predicates such as `cd/1` accessible) and then:

```
?- cd('$/examples').
```

(in Ciao the sequence `$/` *at the beginning of a path name* is replaced by the path of the Ciao root directory).

For more information see Chapter 5 [The interactive top-level shell], page 37.

2.3.4 Generating executables (Un*x)

Executables can be generated from the top-level shell (using `make_exec/2`) or using the standalone compiler (`ciaoc`). To be able to make an executable, the file should define the predicate `main/1` (or `main/0`), which will be called upon startup (see the corresponding manual section for details). In its simplest use, given a top-level *foo*`.pl` file for an application, the compilation process produces an executable `foo`, automatically detecting which other files used by `foo.pl` need recompilation.

For example, within the `examples` directory, you can type:

```
?- make_exec(hw,_).
```

which should produce an executable. Typing `hw` in a shell (or double-clicking on the icon from a graphical window) should execute it.

For more information see Chapter 5 [The interactive top-level shell], page 37 and Chapter 4 [The stand-alone command-line compiler], page 29.

2.3.5 Running Ciao scripts (Un*x)

Ciao allows writing Prolog scripts. These are files containing Prolog source but which get executed without having to explicitly compile them (in the same way as, e.g., `.bat` files or programs in scripting languages). As an example, you can run the file `hw` in the `examples` directory of the Ciao distribution and look at the source with an editor. You can try changing the `Hello world` message and running the program again (no need to recompile!).

As you can see, the file should define the predicate `main/1` (not `main/0`), which will be called upon startup. The two header lines are necessary in Un*x in. In Windows you can leave them in or you can take them out, but you need to rename the script to `hw.pls`. Leaving the lines in has the advantage that the script will also work in Un*x without any change.

For more information see Chapter 8 [The script interpreter], page 59.

2.3.6 The Ciao initialization file (Un*x)

The Ciao toplevel can be made to execute upon startup a number of commands (such as, e.g., loading certain files or setting certain Prolog flags) contained in an initialization file. This file should be called `.ciaorc` and placed in your *home* directory (e.g., `~`, the same in which the `.emacs` file is put). You may need to set the environment variable `HOME` to the path of this directory for the Ciao toplevel shell to be able to locate this file on startup.

2.3.7 Printing manuals (Un*x)

As mentioned before, the manual is available in several formats in the `reference` directory within the `doc` directory in the Ciao distribution, including `postscript` or `pdf`, which are specially useful for printing. These files are also available in the `DOCROOT` directory specified during installation. Printing can be done using an application such as `ghostview` (freely available from `http://www.cs.wisc.edu/~ghost/index.html`) or `acrobat reader` (`http://www.adobe.com`, only `pdf`).

2.4 An introduction to the Ciao emacs environment (Un*x)

While it is easy to use Ciao with any editor of your choice, using it within the `emacs` editor/program development system is highly recommended: Ciao includes an `emacs` *mode* which provides a very complete *application development environment* which greatly simplifies many program development tasks. See Chapter 10 [Using Ciao inside GNU emacs], page 63 for details on the capabilities of `ciao/ emacs` combination.

If the (freely available) `emacs` editor/environment is not installed in your system, we highly recommend that you also install it at this point (there are instructions for where to find `emacs` and how to install it in the Ciao installation instructions). After having done this you can try for example the following things:

- A few basic things:
  - Typing ⟨^H⟩ ⟨i⟩ (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
  - When opening a Prolog file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
  - Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨l⟩) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

  Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

  (if these things do not work the system or emacs may not be installed properly).
- You can go to the location of most of the errors that may be reported during compilation by typing ⟨^C⟩ ⟨`⟩.
- You can also, e.g., create executables from the `Ciao/Prolog` menu, as well as compile individual files, or generate active modules.
- Loading a file for source-level debugging using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨d⟩) and then issuing a query should start the source-level debugger and move a marker on the code in a window while execution is stepped through in the window running the Ciao top level.

- You can add the lines needed in Un*x for turning any file defining `main/1` into a script from the Ciao/Prolog menu or by typing ⟨^C⟩ ⟨I⟩ ⟨S⟩.
- You can also work with the preprocessor and auto-documenter directly from emacs: see their manuals or browse through the corresponding menus that appear when editing `.pl` files.

We encourage you once more to read Chapter 10 [Using Ciao inside GNU emacs], page 63 to discover the many other functionalities of this environment.

2.5 Keeping up to date (Un*x)

You may want to read Chapter 202 [Beyond installation], page 749 for instructions on how to sign up on the Ciao user's mailing list, receive announcements regarding new versions, download new versions, report bugs, etc.

3 Getting started on Windows machines

Author(s): M.Hermenegildo.

This part guides you through some very basic first steps with Ciao on an MSWindows ("Win32") system. It assumes that Ciao is already installed correctly on your Windows system. If this is not the case, then follow the instructions in Chapter 201 [Installing Ciao from a Win32 binary distribution], page 745 (or Chapter 200 [Installing Ciao from the source distribution], page 735) first.

We start with by describing the basics of using Ciao from the Windows explorer and/or a DOS command shell. We strongly recommend reading also Section 3.3 [An introduction to the Ciao emacs environment (Win32)], page 25 for the basics on using Ciao under `emacs`, which is a much simpler and much more powerful way of developing Ciao programs, and has the advantage of offering an almost identical environment under Windows and Un*x.

3.1 Testing your Ciao Win32 installation

It is a good idea to start by performing some tests to check that Ciao is installed correctly on your system (these are the same tests that you are instructed to do during installation, so you can obviously skip them if you have done them already at that time):

- Ciao-related file types (`.pl` source files, `.cpx` executables, `.itf`,`.po`,`.asr` interface files, `.pls` scripts, etc.) should have specific icons associated with them (you can look at the files in the folders in the Ciao distribution to check).
- Double-clicking on the shortcut to `ciaosh(.cpx)` on the desktop should start the typical Prolog top-level shell in a window. If this shortcut has not been created on the desktop, then double-clicking on the `ciaosh(.cpx)` icon inside the `shell` folder within the Ciao source folder should have the same effect.
- In the top-level shell, Prolog library modules should load correctly. Type for example `use_module(library(dec10_io)).` at the Ciao top-level prompt –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.

Also, the following documentation-related actions should work:

- Double-clicking on the shortcut to `ciao(.html)` which appears on the desktop should show the Ciao manual in your default WWW browser. If this shortcut has not been created you can double-click on the `ciao(.html)` file in the `doc\reference\ciao_html` folder inside the Ciao source folder. Make sure you configure your browser to use *style sheets* for correct formatting of the manual (note, however, that some older versions of Explorer did not support style sheets well and will give better results turning them off).
- The `doc\reference` folder contains the manual also in the other formats present in the distribution, such as `info` (very convenient for users of the `emacs` editor/program development system) and `postscript` or `pdf`, which are specially useful for printing. See Section 3.2.7 [Printing manuals (Win32)], page 25 for instructions.

3.2 Using Ciao from the Windows explorer and command shell

3.2.1 Starting/exiting the top-level shell (Win32)

The basic methods for starting/exiting the top-level shell have been discussed above. The installation script also leaves a `ciaosh(.bat)` file inside the `shell` folder of the Ciao distribution which can be used to start the top-level shell from the command line in Windows95/98/NT.

3.2.2 Getting help (Win32)

The basic methods for accessing the manual on-line have also been discussed above. Use the table of contents and the indices of *predicates*, *libraries*, *concepts*, etc. to find what you are looking for. Context-sensitive help is available within the `emacs` environment (see below).

3.2.3 Compiling and running programs (Win32)

Once the shell is started, you can compile and execute Prolog modules inside the interactive toplevel shell in the standard way. E.g., type `use_module(`*file*`).`, `use_module(library(`*file*`)).` for library modules, `ensure_loaded(`*file*`).` for files which are not modules, and `use_package(`*file*`).` for library packages (these are syntactic/semantic packages that extend the Ciao Prolog language in many different ways). Note that the use of `compile/1` and `consult/1` is discouraged in Ciao.

For example, you may want to type `use_package(iso)` to ensure Ciao has loaded all the ISO builtins (whether this is done by default or not depends on your `.ciaorc` file). Do not worry about any "module already in executable" messages –these are normal and simply mean that a certain module is already pre-loaded in the toplevel shell. At this point, typing `write(hello).` should work.

Note that some predicates that may be built-ins in other Prologs are available through libraries in Ciao. This facilitates making small executables.

To change the working directory to, say, the `examples` directory in the Ciao source directory, first do:

```
?- use_module(library(system)).
```

(loading the `system` library makes a number of system-related predicates such as `cd/1` accessible) and then:

```
?- cd('$/examples').
```

(in Ciao the sequence `$/` *at the beginning of a path name* is replaced by the path of the Ciao root directory).

For more information see Chapter 5 [The interactive top-level shell], page 37.

3.2.4 Generating executables (Win32)

Executables can be generated from the toplevel shell (using `make_exec/2`) or using the standalone compiler (`ciaoc(.cpx)`, located in the `ciaoc` folder). To be able to make an executable, the file should define the predicate `main/1` (or `main/0`), which will be called upon startup (see the corresponding manual section for details).

For example, within the `examples` directory, you can type:

```
?- make_exec(hw,_).
```

which should produce an executable. Double-clicking on this executable should execute it.

Another way of creating Ciao executables from source files is by right-clicking on `.pl` files and choosing "make executable". This uses the standalone compiler (this has the disadvantage, however, that it is sometimes difficult to see the error messages).

For more information see Chapter 5 [The interactive top-level shell], page 37 and Chapter 4 [The stand-alone command-line compiler], page 29.

3.2.5 Running Ciao scripts (Win32)

Double-clicking on files ending in `.pls`, *Ciao Prolog scripts*, will also execute them. These are files containing Prolog source but which get executed without having to explicitly compile them (in the same way as, e.g., `.bat` files or programs in scripting languages). As an example, you can double-click on the file `hw.pls` in the `examples` folder and look at the source with an editor. You can try changing the `Hello world` message and double-clicking again (no need to recompile!).

As you can see, the file should define the predicate `main/1` (not `main/0`), which will be called upon startup. The two header lines are only necessary in Un*x. In Windows you can leave them in or you can take them out, but leaving them in has the advantage that the script will also work in Un*x without any change.

For more information see Chapter 8 [The script interpreter], page 59.

3.2.6 The Ciao initialization file (Win32)

The Ciao toplevel can be made to execute upon startup a number of commands (such as, e.g., loading certain files or setting certain Prolog flags) contained in an initialization file. This file should be called `.ciaorc` and placed in your *home* folder (e.g., the same in which the `.emacs` file is put). You may need to set the environment variable `HOME` to the path of this folder for the Ciao toplevel shell to be able to locate this file on startup.

3.2.7 Printing manuals (Win32)

As mentioned before, the manual is available in several formats in the `reference` folder within Ciao's `doc` folder, including `postscript` or `pdf`, which are specially useful for printing. This can be done using an application such as `ghostview` (freely available from `http://www.cs.wisc.edu/~ghost/index.html`) or `acrobat reader` (`http://www.adobe.com`, only `pdf`).

3.3 An introduction to the Ciao emacs environment (Win32)

While it is easy to use Ciao with any editor of your choice, using it within the `emacs` editor/program development system is highly recommended: Ciao includes an `emacs` *mode* which provides a very complete *application development environment* which greatly simplifies many program development tasks. See Chapter 10 [Using Ciao inside GNU emacs], page 63 for details on the capabilities of `ciao/ emacs` combination.

If the (freely available) `emacs` editor/environment is not installed in your system, we highly recommend that you also install it at this point (there are instructions for where to find `emacs` and how to install it in the Ciao installation instructions). After having done this you can try for example the following things:

- A few basic things:
  - Typing ⟨^H⟩ i (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
  - When opening a Prolog file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
  - Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ l) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

(if these things do not work the system or emacs may not be installed properly).

- You can go to the location of most of the errors that may be reported during compilation by typing ⟨^C⟩ ⟨`⟩.
- You can also, e.g., create executables from the `Ciao/Prolog` menu, as well as compile individual files, or generate active modules.
- Loading a file for source-level debugging using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨d⟩) and then issuing a query should start the source-level debugger and move a marker on the code in a window while execution is stepped through in the window running the Ciao top level.
- You can add the lines needed in Un*x for turning any file defining `main/1` into a script from the Ciao/Prolog menu or by typing ⟨^C⟩ ⟨I⟩ ⟨S⟩.
- You can also work with the preprocessor and auto-documenter directly from emacs: see their manuals or browse through the corresponding menus that appear when editing `.pl` files.

We encourage you once more to read Chapter 10 [Using Ciao inside GNU emacs], page 63 to discover the many other functionalities of this environment.

3.4 Keeping up to date (Win32)

You may want to read Chapter 202 [Beyond installation], page 749 for instructions on how to sign up on the Ciao user's mailing list, receive announcements regarding new versions, download new versions, report bugs, etc.

PART I - The program development environment

This part documents the components of the basic Ciao program development environment. They include:

ciaoc: the standalone compiler, which creates executables without having to enter the interactive top-level.

ciaosh: (also invoked simply as `ciao`) is an interactive top-level shell, similar to the one found on most Prolog systems (with some enhancements).

debugger.pl:
a Byrd box-type debugger, similar to the one found on most Prolog systems (also with some enhancements, such as source-level debugging). This is not a standalone application, but is rather included in `ciaosh`, as is done in other Prolog systems. However, it is also *embeddable*, in the sense that it can be included as a library in executables, and activated dynamically and conditionally while such executables are running.

ciao-shell: an interpreter/compiler for *Prolog scripts* (i.e., files containing Prolog code which run without needing explicit compilation).

ciao.el: a *complete program development enviroment*, based on GNU emacs, with syntax coloring, direct access to all the tools described above (as well as the preprocessor and the documenter), atomatic location of errors, source-level debugging, context-sensitive access to on-line help/manuals, etc. The use of this environment is *very highly recommended*!

The Ciao program development environment also includes `ciaopp`, the preprocessor, and `lpdoc`, the documentation generator, which are described in separate manuals.

4 The stand-alone command-line compiler

Author(s): Daniel Cabeza and the CLIP Group.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#30 (2000/11/3, 16:42:1 CET)

`ciaoc` [CH00b] is the Ciao stand-alone command-line compiler. `ciaoc` can be used to create executables or to compile individual files to object code (to be later linked with other files). `ciaoc` is specially useful when working from the command line. Also, it can be called to compile Ciao programs from other tools such as, e.g., shell scripts, `Makefiles`, or project files. All the capabilities of `ciaoc` are also available from the interactive top-level shell, which uses the ciaoc modules as its components.

4.1 Introduction to building executables

An *executable* can be built from a single file or from a collection of inter-related files. In the case of only one file, this file must define the predicate `main/0` or `main/1`. This predicate is the one which will be called when the executable is started. As an example, consider the following file, called `hello.pl`:

```
main :-
     write('Hello world'),
     nl.
```

To compile it from the command line using the `ciaoc` standalone compiler it suffices to type "`ciaoc hello`" (in Win32 you may have to put the complete path to the `ciaoc` folder of the Ciao distribution, where the installation process leaves a `ciaoc.bat` file):

```
/herme@clip:/tmp
[60]> ciaoc hello

/herme@clip:/tmp
[61]>
```

This produces an executable called `hello` in Un*x-like systems and `hello.cpx` under Win32 systems. This executable can then be run in Win32 by double-clicking on it and on Un*x systems by simply typing its name (see for Section 4.3 [Running executables from the command line], page 30 for how to run executables from the command line in Win32):

```
/herme@clip:/tmp
[61]> hello
Hello world
```

If the application is composed of several files the process is identical. Assume `hello.pl` is now:

```
:- use_module(aux,[p/1]).

main :-
     p(X),
     write(X),
     nl.
```

where the file `aux.pl` contains:

```
:- module(aux,[p/1]).

p('Hello world').
```

This can again be compiled using the `ciaoc` standalone compiler as before:

```
/herme@clip:/tmp
[60]> ciaoc hello

/herme@clip:/tmp
[61]> hello
Hello world
```

The invocation of `ciaoc hello` compiles the file `hello.pl` and all connected files that may need recompilation – in this case the file `aux.pl`. Also, if any library files used had not been compiled previously they would be compiled at this point (See Section 4.6 [Intermediate files in the compilation process], page 33). Also, if, say, `hello.pl` is changed and recompiled, the object code resulting from the previous compilation of `aux.pl` will be reused. This is all done without any need for `Makefile`s, and considerably accelerates the development process for large applications. This process can be observed by selecting the `-v` option when invoking `ciaoc` (which is equivalent to setting the `verbose_compilation` Prolog flag to `on` in the top-level interpreter).

If `main/1` is defined instead of `main/0` then when the executable is started the argument of `main/1` will be instantiated to a list of atoms, each one of them corresponding to a command line option. Consider the file `say.pl`:

```
main(Argv) :-
     write_list(Argv), nl.

write_list([]).
write_list([Arg|Args]) :-
     write(Arg),
     write(' '),
     write_list(Args).
```

Compiling this program and running it results in the following output:

```
/herme@clip:/tmp
[91]> ciaoc say

/herme@clip:/tmp
[91]> say hello dolly
hello dolly
```

The name of the generated executable can be controlled with the `-o` option (See Section 4.7 [Usage (ciaoc)], page 34).

4.2 Paths used by the compiler during compilation

The compiler will look for files mentioned in commands such as `use_module/1` or `ensure_loaded/1` in the current directory. Other paths can be added by including them in a file whose name is given to `ciaoc` using the `-u` option. This file should contain facts of the predicates `file_search_path/2` and `library_directory/1` (see the documentation for these predicates and also Chapter 9 [Customizing library paths and path aliases], page 61 for details).

4.3 Running executables from the command line

As mentioned before, what the `ciaoc` compiler generates and how it is started varies somewhat from OS to OS. In general, the product of compiling an application with `ciaoc` is a file that contains the bytecode (the product of the compilation) and invokes the Ciao engine on it.

- Un Un*x this is a *script* (see the first lines of the file) which invokes the ciao engine on this file. To run the generated executable from a Un*x shell, or from the `bash` shell that comes with the Cygwin libraries (see Section 200.6 [Installation and compilation under Windows], page 740) it suffices to type its name at the shell command line, as in the examples above.
- In a Win32 system, the compiler produces a similar file with a `.cpx` ending. The Ciao installation process typically makes sure that the Windows registry contains the right entries so that this executable will run upon double-cliking on it.

  In you want to run the executable from the command line an additional `.bat` file is typically needed. To help in doing this, the Win32 installation process creates a `.bat` skeleton file called `bat_skel` in the `Win32` folder of the distribution) which allows running Ciao executables from the command line. If you want to run a Ciao executable `file.cpx` from the command line, you normally copy the skeleton file to the folder were the executable is and rename it to `file.bat`, then change its contents as explained in a comment inside the file itself.

  Note that this `.bat` file is usually not necessary in NT, as its command shell understands file extension associations. I.e., in windows NT it is possible to run the `file.cpx` executable directly. Due to limitations of `.bat` files in Windows 95/98, in those OSs no more than 9 command line arguments can be passed to the executable (in NT there is no such restriction).

  Finally, in a system in which Cygnus Win32 is installed executables can also be used directly from the `bash` shell command line, without any associated `.bat` files, by simply typing their name at the `bash` shell command line, in the same way as in Un*x. This only requires that the `bash` shell which comes with Cygnus Win32 be installed and accessible: simply, make sure that `/bin/sh.exe` exists.

Except for a couple of header lines, the contents of executables are almost identical under different OSs (except for self-contained ones). The bytecode they contain is architecture-independent. In fact, it is possible to create an executable under Un*x and run it on Windows or viceversa, by making only minor modifications (e.g., creating the `.bat` file and/or setting environment variables or editing the start of the file to point to the correct engine location).

4.4 Types of executables generated

While the default options used by `ciaoc` are sufficient for normal use, by selecting other options `ciaoc` can generate several different types of executables, which offer interesting tradeoffs among size of the generated executable, portability, and startup time [CH00b]:

Dynamic executables:

`ciaoc` produces by default *dynamic* executables. In this case the executable produced is a platform-independent file which includes in compiled form all the user defined files. On the other hand, any system libraries used by the application are loaded dynamically at startup. More precisely, any files that appear as `library(...)` in `use_module/1` and `ensure_loaded/1` declarations will not be included explicitly in the executable and will instead be loaded dynamically. Is is also possible to mark other path aliases (see the documentation for `file_search_path/2`) for dynamic loading by using the `-d` option. Files accessed through such aliases will also be loaded dynamically.

Dynamic loading allows making smaller executables. Such executables may be used directly in the same machine in which they were compiled, since suitable paths to the location of the libraries will be included as default in the executable by `ciaoc` during compilation.

The executable can also be used in another machine, even if the architecture and OS are different. The requirement is that the Ciao libraries (which will also include the appropriate Ciao engine for that architecture and OS) be installed in the target

machine, and that the `CIAOLIB` and `CIAOENGINE` environment variables are set appropriately for the executable to be able to find them (see Section 4.5 [Environment variables used by Ciao executables], page 33). How to do this differs slightly from OS to OS.

Static executables:
: Selecting the `-s` option `ciaoc` produces a *static* executable. In this case the executable produced (again a platform-independent file) will include in it all the auxiliary files and any system libraries needed by the application. Thus, such an executable is almost complete, needing in order to run only the Ciao engine, which is platform-specific.[1] Again, if the executable is run in the same machine in which it was compiled then the engine is found automatically. If the executable is moved to another machine, the executable only needs access to a suitable engine (which can be done by setting the `CIAOENGINE` environment variable to point to this engine).

  This type of compilation produces larger executables, but has the advantage that these executables can be installed and run in a different machine, with different architecture and OS, even if Ciao is not installed on that machine. To install (or distribute) such an executable, one only needs to copy the executable file itself and the appropriate engine for the target platform (See Chapter 200 [Installing Ciao from the source distribution], page 735 or Chapter 201 [Installing Ciao from a Win32 binary distribution], page 745 and Section 200.5 [Multiarchitecture support], page 740), and to set things so that the executable can find the engine.[2]

Dynamic executables, with lazy loading:
: Selecting the `-l` option is very similar to the case of dynamic executables above, except that the code in the library modules is not loaded when the program is started but rather it is done during execution, the first time a predicate defined in that file is called. This is advantageous if a large application is composed of many parts but is such that typically only some of the parts are used in each invocation. The Ciao preprocessor, `ciaopp`, is a good example of this: it has many capabilitites but typically only some of them are used in a given session. An executable with lazy load has the advantage that it starts fast, loading a minimal functionality on startup, and then loads the different modules automatically as needed.

Self-contained executables:
: *Self-contained* executables are static executables (i.e., this option also implies *static* compilation) which include a Ciao engine along with the bytecode, so they do not depend on an external one for their execution. This is useful to create executables which run even if the machine where the program is to be executed does not have a Ciao engine installed and/or libraries. The disadvantage is that such execuatbles are platform-dependent (as well as larger than those that simply use an external library). This type of compilation is selected with the `-S` option. Cross-compilation is also possible with the `-SS` option, so you can specify the target OS and architecture (e.g.

---

[1] Currently there is an exception to this related to libraries which are written in languages other than Prolog, as, e.g., C. C files are currently always compiled to dynamically loadable object files (`.so` files), and they thus need to be included manually in a distribution of an application. This will be automated in upcoming versions of the Ciao system.

[2] It is also possible to produce real standalone executables, i.e., executables that do not need to have an engine around. However, this is not automated yet, although it is planned for an upcoming version of the compiler. In particular, the compiler can generate a `.c` file for each `.pl` file. Then all the `.c` files can be compiled together into a real executable (the engine is added one more element during link time) producing a complete executable for a given architecture. The downside of course is that such an executable will not be portable to other architectures without recompilation.

LINUXi86). To be able to use the latter option, it is necessary to have installed a ciaoengine for the target machine in the Ciao library (this requires compiling the engine in that OS/architecture and installing it, so that it is available in the library).

Compressed executables:
: In *compressed* executables the bytecode is compressed. This allows producing smaller executables, at the cost of a slightly slower startup time. This is selected with the `-z` option. You can also produce compressed libraries if you use `-zl` along with the `-c` option. If you select `-zl` while generating an executable, any library which is compiled to accomplish this will be also compressed.

Active modules:
: The compiler can also compile (via the `-a` option) a given file into an *active module* (see Chapter 93 [Active modules (high-level distributed execution)], page 359 for a description of this).

4.5 Environment variables used by Ciao executables

The executables generated by the Ciao compiler (including the ciao development tools themselves) locate automatically where the Ciao engine and libraries have been installed, since those paths are stored as defaults in the engine and compiler at installation time. Thus, there is no need for setting any environment variables in order to *run* Ciao executables (on a single architecture – see Section 200.5 [Multiarchitecture support], page 740 for running on multiple architectures).

However, the default paths can be overridden by using the environment variables `CIAOENGINE` and `CIAOLIB`. The first one will tell the Ciao executables where to look for an engine, and the second will tell them where to look for the libraries. Thus, it is possible to actually use the Ciao system without installing it by setting these variables to the following values:

- `CIAOENGINE`: `$(SRC)/bin/$(CIAOARCH)/ciaoengine`
- `CIAOLIB`: `$(SRC)`

where `$(CIAOARCH)` is the string echoed by the command `SRC/etc/ciao_get_arch` (or `BINROOT/ciao_get_arch`, after installation).

This allows using alternate engines or libraries, which can be very useful for system development and experimentation.

4.6 Intermediate files in the compilation process

Compiling an individual source (i.e., `.pl`) file produces a `.itf` file and a `.po` file. The `.itf` file contains information of the *modular interface* of the file, such as information on exported and imported predicates and on the other modules used by this module. This information is used to know if a given file should be recompiled at a given point in time and also to be able to detect more errors statically including undefined predicates, mismatches on predicate charaterictics across modules, etc. The `.po` file contains the platform-independent object code for a file, ready for linking (statically or dynamically).

It is also possible to use `ciaoc` to explicitly generate the `.po` file for one or more `.pl` files by using the `-c` option.

4.7 Usage (ciaoc)

The following provides details on the different command line options available when invoking `ciaoc`:

```
ciaoc <MiscOpts> <ExecOpts> [-o <execname>] <file> ...

  Make an executable from the listed files.  If there is
  more than one file, they must be non-module, and the
  first one must include the main predicate.  The -o
  option allows generating an arbitrary executable name.

ciaoc <MiscOpts> <ExecOpts> -a <publishmod> <module>

  Make an active module executable from <module> with
  address publish module <publishmod>.

ciaoc <MiscOpts> -c  <file> ...

  Compile listed files (make .po objects).

<MiscOpts> can be: [-v] [-ri] [-u <file>]

-v  verbose mode

-ri generate human readable .itf files

-u  use <file> for compilation

<ExecOpts> can be: [-s|-S|-SS <target>|-z|-zl|-e|-l|(-ll <module>)*]
                   (-d <alias>)* [-x]

-s  make a static executable (otherwise dynamic files are not included)

-S  make standalone executable for the current OS and architecture

-SS make standalone executable for <target> OS and architecture
    valid <target> values may be: LINUXi86, SolarisSparc...

    (both -S and -SS imply -s)

-z  generate executables with compressed bytecode

-zl generate libraries with compressed bytecode - any library (re)compiled
    as consequence of normal executable compilation will also be affected

-e  make executable with eager load of dynamic files at startup (default)

-l  idem with lazy load of dynamic files (except insecure cases)

-ll force <module> to be loaded lazily,  implies -l

-d  files using this path alias are dynamic (default: library)

-x  Extended recompilation: only useful for Ciao standard library developers
```

```
default extension for files is '.pl'
```

5 The interactive top-level shell

Author(s): Daniel Cabeza and the CLIP Group.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#129 (2001/10/28, 15:38:52 CET)

`ciaosh` is the Ciao interactive top-level shell. It provides the user with an interactive programming environment with tools for incrementally building programs, debugging programs by following their executions, and modifying parts of programs without having to start again from scratch. If available, it is strongly recommended to use it with the emacs interface provided, as it greatly simplifies the operation. This chapter documents general operation in the shell itself. Other chapters document the

5.1 Shell invocation and startup

When invoked, the shell responds with a message of identification and the prompt `?-` as soon as it is ready to accept input, thus:

```
Ciao-Prolog X.Y #PP: Thu Mar 25 17:20:55 MET 1999
?-
```

When the shell is initialized it looks for a file `.ciaorc` in the HOME directory and makes an `include` of it, if it exists. This file is useful for including `use_module/1` declarations for the modules one wants to be loaded by default, changing prolog flags, etc. (Note that the `.ciaorc` file can only contain directives, not actual code; to load some code at startup put it in a separate file and load it using e.g. a `use_module/1` declaration.) If the initialization file does not exist, the ISO-Prolog compatibility package `iso` is included, to provide (almost) all the ISO builtins by default. Two command-line options control the loading of the initialization file:

`-f` Fast start, do not load any initialization file.

`-l File` Look for initialization file `File` instead of `~/.ciaorc`. If it does not exist, include the compatibility package `iso`.

5.2 Shell interaction

After the shell outputs the prompt, it is expecting either an internal command (see the following sections) or a *query* (a goal or sequence of goals). When typing in the input, which must be a valid prolog term, if the term does not end in the first line, subsequent lines are indented. For example:

```
?- X =
   f(a,
   b).

X = f(a,b) ?

yes
?-
```

The queries are executed by the shell as if they appeared in the user module. Thus, in addition to builtin predicates, predicates available to be executed directly are all predicates defined by loaded user files (files with no module declaration), and imported predicates from modules by the use of `use_module`.

The possible answers of the shell, after executing an internal command or query, are:

- If the execution failed (or produced an error), the answer is `no`.

- If the execution was successful, and no answer variable (see below) was bound (or constraints where imposed on such variables), the answer is simply `yes`.
- If the execution was successful and bindings where made (or constraints where imposed) on answer variables, then the shell outputs the values of answer variables, as a sequence of bindings (or constraints), and then prints a `?` as a prompt. At this point it is expecting an input line from the user. By entering a carriage-return (⟨RET⟩) or any line starting with `y`, the query terminates and the shell answer `yes`. Entering a '`,`' the shell enters a recursive level (see below). Finally, any other answer forces the system to backtrack and look for the next solution (answering as with the first solution).

To allow using connection variables in queries without having to report their results, variables whose name starts with `_` are not considered in answers, the rest being the *answer variables*. This example illustrates the previous points:

```
?- member(a, [b, c]).

no
?- member(a, [a, b]).

yes
?- member(X, [a|L]).

X = a ? ;

L = [X|_] ?

yes
?- atom_codes(ciao, _C), member(L, _C).

L = 99 ? ;

L = 105 ? ;

L = 97 ? ;

L = 111 ? ;

no
?-
```

5.3 Entering recursive (conjunctive) shell levels

As stated before, when the user answers with '`,`' after a solution is presented, the shell enters a *recursive level*, changing its prompt to *N* `?-` (where *N* is the recursion level) and keeping the bindings or constraints of the solution (this is inspired by the *LogIn* language developed by *H. Ait-Kaci*, *P. Lincoln* and *Roger Nasr* [AKNL86]). Thus, the following queries will be executed within that context, and all variables in the lower level solutions will be reported in subsequent solutions at this level. To exit a recursive level, input an ⟨EOF⟩ character or the command `up`. The last solution after entering the level is repeated, to allow asking for more solutions. Use command `top` to exit all recursive levels and return to the top level. Example interaction:

```
?- directory_files('.',_Fs), member(F,_Fs).

F = 'file_utils.po' ? ,
```

```
1 ?- file_property(F, mod_time(T)).

F = 'file_utils.po',
T = 923497679 ?

yes
1 ?- up.

F = 'file_utils.po' ? ;

F = 'file_utils.pl' ? ;

F = 'file_utils.itf' ? ,

1 ?- file_property(F, mod_time(T)).

F = 'file_utils.itf',
T = 923497679 ?

yes
1 ?- ^D
F = 'file_utils.itf' ?

yes
?-
```

5.4 Usage and interface (`ciaosh`)

- **Library usage:**

  The following predicates can be used at the top-level shell natively (but see also the commands available in Chapter 6 [The interactive debugger], page 45 which are also available within the top-level shell).
- **Exports:**
  - *Predicates:*

    `use_module/1`, `use_module/2`, `ensure_loaded/1`, `make_exec/2`, `include/1`, `use_package/1`, `consult/1`, `compile/1`, `./2`, `make_po/1`, `unload/1`, `set_debug_mode/1`, `set_nodebug_mode/1`, `make_actmod/2`, `force_lazy/1`, `undo_force_lazy/1`, `dynamic_search_path/1`, `multifile/1`.
- **Other modules used:**
  - *Application modules:*

    `library(ciaosh)`.
  - *System library modules:*

    `libpaths`, `compiler/compiler`, `compiler/exemaker`, `compiler/c_itf`, `debugger/debugger`.

5.5 Documentation on exports (ciaosh)

use_module/1: PREDICATE

Usage: `use_module(Module)`

- *Description:* Load into the top-level the module defined in `Module`, importing all the predicates it exports.
- *The following properties should hold at call time:*

  `Module` is a source name. (`streams_basic:sourcename/1`)

use_module/2: PREDICATE

Usage: `use_module(Module,Imports)`

- *Description:* Load into the top-level the module defined in `Module`, importing the predicates in `Imports`.
- *The following properties should hold at call time:*

  `Module` is a source name. (`streams_basic:sourcename/1`)

  `Imports` is a list of `prednames`. (`basic_props:list/2`)

ensure_loaded/1: PREDICATE

Usage: `ensure_loaded(File)`

- *Description:* Load into the top-level the code residing in file (or files) `File`, which is user (i.e. non-module) code.
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (`ciaosh_doc:sourcenames/1`)

make_exec/2: PREDICATE

Usage: `make_exec(File,ExecName)`

- *Description:* Make a Ciao executable from file (or files) `File`, giving it name `ExecName`. If `ExecName` is a variable, the compiler will choose a default name for the executable and will bind the variable `ExecName` to that name. The name is chosen as follows: if the main prolog file has no `.pl` extension or we are in Windows, the executable will have extension `.cpx`; else the executable will be named as the main prolog file without extension.
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (`ciaosh_doc:sourcenames/1`)
- *The following properties hold upon exit:*

  `ExecName` is an atom. (`basic_props:atm/1`)

include/1: PREDICATE

Usage: `include(File)`

- *Description:* The contents of the file `File` are included in the top-level shell. For the moment, it only works with some directives, which are interpreted by the shell, or with normal clauses (which are asserted), if library(dynamic) is loaded beforehand.
- *The following properties should hold at call time:*

  `File` is a source name. (`streams_basic:sourcename/1`)

use_package/1: PREDICATE

Usage: `use_package(Package)`

- *Description:* Equivalent to issuing an include(library(`Package`)) for each listed file. By now some package contents cannot be handled.
- *The following properties should hold at call time:*

  `Package` is a source name or a list of source names. (`ciaosh_doc:sourcenames/1`)

consult/1: PREDICATE

Usage: `consult(File)`

- *Description:* Provided for backward compatibility. Similar to `ensure_loaded/1`, but ensuring each listed file is loaded in consult mode (see Chapter 6 [The interactive debugger], page 45).
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (`ciaosh_doc:sourcenames/1`)

compile/1: PREDICATE

Usage: `compile(File)`

- *Description:* Provided for backward compatibility. Similar to `ensure_loaded/1`, but ensuring each listed file is loaded in compile mode (see Chapter 6 [The interactive debugger], page 45).
- *The following properties should hold at call time:*

  `File` is a source name or a list of source names. (`ciaosh_doc:sourcenames/1`)

./2: PREDICATE

Usage: `[File|Files]`

- *Description:* Provided for backward compatibility, obsoleted by `ensure_loaded/1`.
- *The following properties should hold at call time:*

  `File` is a source name. (`streams_basic:sourcename/1`)

  `Files` is a list of `sourcenames`. (`basic_props:list/2`)

make_po/1: PREDICATE

Usage: `make_po(Files)`

- *Description:* Make object (`.po`) files from `Files`. Equivalent to executing `"ciaoc -c"` on the files.
- *The following properties should hold at call time:*

  `Files` is a source name or a list of source names. (`ciaosh_doc:sourcenames/1`)

unload/1: PREDICATE

Usage: `unload(File)`

- *Description:* Unloads dynamically loaded file `File`.
- *The following properties should hold at call time:*

  `File` is a source name. (`streams_basic:sourcename/1`)

set_debug_mode/1: PREDICATE

Usage: `set_debug_mode(File)`

- *Description:* Set the loading mode of `File` to *consult*. See Chapter 6 [The interactive debugger], page 45.
- *The following properties should hold at call time:*

  `File` is a source name. (`streams_basic:sourcename/1`)

set_nodebug_mode/1: PREDICATE

Usage: `set_nodebug_mode(File)`

- *Description:* Set the loading mode of `File` to *compile*. See Chapter 6 [The interactive debugger], page 45.
- *The following properties should hold at call time:*

  `File` is a source name. (`streams_basic:sourcename/1`)

make_actmod/2: PREDICATE

Usage: `make_actmod(ModuleFile,PublishMod)`

- *Description:* Make an active module executable from the module residing in `ModuleFile`, using address publish module of name `PublishMod` (which needs to be in the library paths).
- *The following properties should hold at call time:*

  `ModuleFile` is a source name. (`streams_basic:sourcename/1`)

  `PublishMod` is an atom. (`basic_props:atm/1`)

force_lazy/1: PREDICATE

Usage: `force_lazy(Module)`

- *Description:* Force module of name `Module` to be loaded lazily in the subsequent created executables.
- *The following properties should hold at call time:*

  `Module` is an atom. (`basic_props:atm/1`)

undo_force_lazy/1: PREDICATE

Usage: `undo_force_lazy(Module)`

- *Description:* Disable a previous `force_lazy/1` on module `Module` (or, if it is uninstantiated, all previous `force_lazy/1`).
- *Calls should, and exit will be compatible with:*

  `Module` is an atom. (`basic_props:atm/1`)

dynamic_search_path/1: PREDICATE

Usage: `dynamic_search_path(Name)`

- *Description:* Asserting a fact to this data predicate, files using path alias `Name` will be treated as dynamic in the subsequent created executables.
- *The following properties should hold at call time:*

  `Name` is an atom. (`basic_props:atm/1`)

multifile/1: PREDICATE

Usage: `multifile Pred`

– *Description:* Dynamically declare predicate `Pred` as multifile. This is useful at the top-level shell to be able to call multifile predicates of loaded files.

– *The following properties should hold at call time:*

`Pred` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(`basic_props:predname/1`)

5.6 Documentation on internals (`ciaosh`)

sourcenames/1: PROPERTY

Is defined as follows:

```
sourcenames(File) :-
        sourcename(File).
sourcenames(Files) :-
        list(Files,sourcename).
```

See `sourcename/1` in Chapter 21 [Basic file/stream handling], page 117

Usage: `sourcenames(Files)`

– *Description:* `Files` is a source name or a list of source names.

6 The interactive debugger

Author(s): D. Cabeza, Manuel C. Rodriguez, (A. Ciepielewski, M. Carlsson, T. Chikayama, K. Shen).

The Ciao program development environment includes a number of advanced debugging tools, such as a source-level debugger, the `ciaopp` preprocessor, and some execution visualizers. Herein we discuss the interactive debugger available in the standard top-level, which allows tracing the control flow of programs, in a similar way to other popular Prolog systems. This is a classical Byrd *box-type debugger* [Byr80,BBP81], with some enhancements, most notably being able to track the execution on the source program. We also discuss the embedded debugger, which is a version of the debugger which can be embedded into executables so that an interactive debugging session can be triggered at any time while running that executable without needing the top-level shell.

Byrd's Procedure Box model of debugging execution provides a simple way of visualising control flow, including backtracking. Control flow is in principle viewed at the predicate level, rather than at the level of individual clauses. The Ciao debugger has the ability to mark selected modules and/or files for debugging (traditional and source debugging), rather than having to exhaustively trace your program. It also allows to selectively set spy-points and breakpoints. Spy-points allow the programmer to nominate interesting predicates at which program execution is to pause so that the programmer can interact with the debugger. Breakpoints are similar to spy-points, but allow pausing at a specific line in the code, corresponding to a particular literal. There is a wide choice of control and information options available during debugging interaction.

Note: While the debugger described herein can be used in a standalone way (i.e., from a operating system shell or terminal window) in the same way as other Prolog debuggers, the most convenient way of debugging Ciao programs is by using the emacs mode (see Chapter 10 [Using Ciao inside GNU emacs], page 63), i.e., debugging from within the `emacs` editor / programming environment.

6.1 Marking modules and files for debugging in the top-level debugger

Usually, when a program is not working properly, the programmer has a feeling of which are the modules where the fault may be. Since full-fledged debugging is only available on *interpreted* (called *interpreted mode* in traditional Prolog systems) modules, which are executed much slower than compiled modules, there is the posibility of telling the top level which particular modules are to be loaded in *interpreted mode*, with the aim of debugging them. The simplest way of achieving this is by executing in the Ciao shell prompt, for each suspicious module `Module` in the program, a command like this:

```
?- debug_module(Module).
```

An alternative way of loading a module in interpreted mode exists which will instruct the debugger to keep track of the line numbers in the source file and to report them during debugging. This feature can be selected for a suspicious module `Module` in the program by executing a command such as:

```
?- debug_module_source(Module).
```

This is most useful when running the top-level inside the `emacs` editor since in that case the Ciao emacs mode allows performing full source-level debugging in each module marked as above, i.e., the source lines being executed will be highlighted dynamically during debugging in a window showing the source code of the module.

Note that all files with no module declaration belong to the pseudo-module `user`, so the command to be issued for debugging a user file, say `foo.pl`, would be `debug_module(user)` or `debug_module_source(user)`, and not `debug_module(foo)`.

The two ways of performing source-level debugging are fully compatible between them, i.e., Ciao allows having some modules loaded with `debug_module/1` and others with `debug_module_source/1`. To change from one interpreted mode to the other mode it suffices to select the module with the new interpreted mode (debugger mode), using the appropiate command, and reload the module.

The commands above perform in fact two related actions: first, they let the compiler know that if a file containing a module with this name is loaded, it should be loaded in interpreted mode (source or traditional). In addition, they instruct the debugger to actually prepare for debugging the code belonging to that module. After that, the modules which are to be debugged have to be (re)loaded so that they are compiled or loaded for interpretation in the appropriate way. The nice thing is that, due to the modular behaviour of the compiler/top-level, if the modules are part of a bigger application, it suffices to load the main module of the application, since this will automatically force the dependent modules which have changed to be loaded in the appropriate way, including those whose *loading mode* has changed (i.e., changing the loading mode has the effect of forcing the required re-loading of the module at the appropriate time).

Later in the debugging process, as the bug location is isolated, typically one will want to restrict more and more the modules where debugging takes place. To this end, and without the need for reloading, one can tell the debugger to not consider a module for debugging issuing a `nodebug_module/1` command, which counteracts a `debug_module/1` or `debug_module_source/1` command with the same module name, and reloading it (or the main file).

There are also two top-level commands `set_debug_mode/1` and `set_nodebug_mode/1`, which accept as argument a file spec (i.e., `library(foo)` or `foo`, even if it is a user file) to be able to load a file in interpreted mode without changing the set of modules that the debugger will try to spy.

6.2 The debugging process

Once modules or user files are marked for debugging and reloaded, the traditional debugging shell commands can be used (the documentation of the `debugger` library following this chapter contains all the commands and their description), with the same meaning as in other classical Prolog systems. The differences in their behavior are:

- Debugging takes place only in the modules in which it was activated,
- `nospy/1` and `spy/1` accept sequences of predicate specs, and they will search for those predicates only in the modules marked for debugging (traditional or source-level debugging).
- `breakpt/6` and `nobreakpt/6` allow setting breakpoints at selected clause literals and will search for those literals only in the modules marked for source-level debugging (modules marked with `debug_module_source/1`).

In particular, the system is initially in nodebug mode, in which no tracing is performed. The system can be put in debug mode by a call to `debug/0` in which execution of queries will proceed until the first *spy-point* or *breakpoint*. Alternatively, the system can be put in trace mode by a call to `trace/0` in which all predicates will be trace.

6.3 Marking modules and files for debugging with the embedded debugger

The embedded debugger, as the interpreted debugger, has three different modes of operation: debug, trace or nodebug. These debuggers modes can be set by adding a package declaration in the module, as follows:

```
:- use_package(debug).
:- use_package(trace).
:- use_package(nodebug).
```

and recompiling the application.

In order to debug, or trace, correctly the complete code these declarations *must* appear the last ones of all `use_package` declarations used. Also it is possible, as usual, to add the debugging package(s) in the module declaration using the predicate `module/3` (and they should also be the last ones).

The embedded debugger has limitations over the interpreted debugger. The most important is that the "retry" option is not available. But it is possible to add, and remove, spy-points and breakpoins using the predicates `spy/1`, `nospy/1`, `breakpt/6` and `nobreakpt/6`, etc. These can be used in a clause declaration or as declarations. Also it is possible to add in the code predicates for issuing the debugger (i.e., use debug mode, and in a clause add the predicate `trace/1`).

The nodebug mode allows keeping the spy-points and breakpoints in the code instead of removing them from the code.

Note that there is a particularly interesting way of using the embedded debugger: if an *application* is run in a shell buffer which has been set with Ciao inferior mode (⟨M-x⟩ `ciao-inferior-mode`) and this application starts emitting output from the embedded debugger (i.e., which contains the embedded debugger and is debugging its code) then the Ciao emacs mode will be able to follow these messages, for example tracking execution in the source level code. This also works if the application is written in a combination of languages, provided the parts written in Ciao are compiled with the embedded debugger package and is thus a covenient way of debugging multi-language applications. The only thing needed is to make sure that the output messages appear in a shell buffer that is in Ciao inferior mode.

See the following as a general example of use of the embedded debugger:

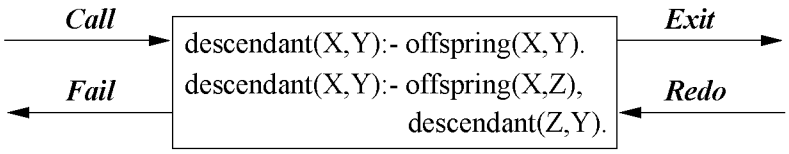
```
:- module( foo,[main/1],[assertions, debug]).

:- entry main/1.

main(X) :-
         display(X),
         spy(foo),
         foo(X),
         notrace,
         nl.

foo([]).
foo([X|T]) :-
        trace,
        bar(X),
        foo(T).

bar(X) :-
        display(X).
```

6.4 The procedure box control flow model

During debugging the interpreter prints out a sequence of goals in various states of instantiation in order to show the state that the program has reached in its execution. However, in order to understand what is occurring it is necessary to understand when and why the interpreter prints out goals. As in other programming languages, key points of interest are procedure entry and return, but in Prolog there is the additional complexity of backtracking. One of the major confusions that novice Prolog programmers have to face is the question of what actually

happens when a goal fails and the system suddenly starts backtracking. The Procedure Box model of Prolog execution views program control flow in terms of movement about the program text. This model provides a basis for the debugging mechanism in the interpreter, and enables the user to view the behaviour of the program in a consistent way. It also provides the basis for the visualization performed on the source level program when source level program when source-level debugging is activated within `emacs`.

Let us look at an example Prolog procedure:



The first clause states that `Y` is a descendant of `X` if `Y` is an offspring of `X`, and the second clause states that `Y` is a descendant of `X` if `Z` is an offspring of `X` and `Y` is a descendant of `Z`. In the diagram a box has been drawn around the whole procedure and labelled arrows indicate the control flow in and out of this box. There are four such arrows which we shall look at in turn.

- **Call**

  This arrow represents initial invocation of the procedure. When a goal of the form `descendant(X,Y)` is required to be satisfied, control passes through the Call port of the descendant box with the intention of matching a component clause and then satisfying any subgoals in the body of that clause. Note that this is independent of whether such a match is possible; i.e. first the box is called, and then the attempt to match takes place. Textually we can imagine moving to the code for descendant when meeting a call to descendant in some other part of the code.

- **Exit**

  This arrow represents a successful return from the procedure. This occurs when the initial goal has been unified with one of the component clauses and any subgoals have been satisfied. Control now passes out of the Exit port of the descendant box. Textually we stop following the code for descendant and go back to the place we came from.

- **Redo**

  This arrow indicates that a subsequent goal has failed and that the system is backtracking in an attempt to find alternatives to previous solutions. Control passes through the Redo port of the descendant box. An attempt will now be made to resatisfy one of the component subgoals in the body of the clause that last succeeded; or, if that fails, to completely rematch the original goal with an alternative clause and then try to satisfy any subgoals in the body of this new clause. Textually we follow the code backwards up the way we came looking for new ways of succeeding, possibly dropping down on to another clause and following that if necessary.

- **Fail**

  This arrow represents a failure of the initial goal, which might occur if no clause is matched, or if subgoals are never satisfied, or if any solution produced is always rejected by later processing. Control now passes out of the Fail port of the descendant box and the system continues to backtrack. Textually we move back to the code which called this procedure and keep moving backwards up the code looking for choice points.

In terms of this model, the information we get about the procedure box is only the control flow through these four ports. This means that at this level we are not concerned with which clause matches, and how any subgoals are satisfied, but rather we only wish to know the initial goal and the final outcome. However, it can be seen that whenever we are trying to satisfy subgoals, what we are actually doing is passing through the ports of *their* respective boxes. If

we were following this (e.g., activating source-level debugging), then we would have complete information about the control flow inside the procedure box.

Note that the box we have drawn around the procedure should really be seen as an invocation box. That is, there will be a different box for each different invocation of the procedure. Obviously, with something like a recursive procedure, there will be many different Calls and Exits in the control flow, but these will be for different invocations. Since this might get confusing each invocation box is given a unique integer identifier in the messages, as described below.

Note that not all procedure calls are traced; there are a few basic predicates which have been made invisible since it is more convenient not to trace them. These include debugging directives, basic control structures, and some builtins. This means that messages will never be printed for these predicates during debugging.

6.5 Format of debugging messages

This section explains the two formats of the message output by the debugger at a port. All trace messages are output to the terminal regardless of where the current output stream is directed (which allows tracing programs while they are performing file I/O). The basic format, which will be shown in traditional debug and in source-level debugging within Ciao `emacs` mode, is as follows:

```
S  13  7  Call: T user:descendant(dani,_123) ?
```

`S` is a spy-point or breakpoint indicator. It is printed as '`+`', indicating that there is a spy-point on `descendant/2` in module `user`, as `'B'` denoting a breakpoint, or as ' ', denoting no spy-point or breakpoint. If there is a spy-point and a breakpoint in the same predicate the spy-point indicator takes preference over breakpoint indicator.

`T` is a subterm trace. This is used in conjunction with the `^` command (set subterm), described below. If a subterm has been selected, `T` is printed as the sequence of commands used to select the subterm. Normally, however, `T` is printed as ' ', indicating that no subterm has been selected.

The first number is the unique invocation identifier. It is always nondecreasing (provided that the debugger is switched on) regardless of whether or not the invocations are being actually seen. This number can be used to cross correlate the trace messages for the various ports, since it is unique for every invocation. It will also give an indication of the number of procedure calls made since the start of the execution. The invocation counter starts again for every fresh execution of a command, and it is also reset when retries (see later) are performed.

The number following this is the *current depth*; i.e., the number of direct *ancestors* this goal has. The next word specifies the particular port (`Call`, `Exit`, `Redo` or `Fail`). The goal is then printed so that its current instantiation state can be inspected. The final `?` is the prompt indicating that the debugger is waiting for user interaction. One of the option codes allowed (see below) can be input at this point.

The second format, quite similar to the format explained above, is shown when using source-level debugging outside the Ciao `emacs` mode, and it is as follows:

```
   In /home/mcarlos/ciao/foo.pl (5-9) descendant-1
S  13  7  Call: T user:descendant(dani,_123) ?
```

This format is identical to the format above except for the first line, which contains the information for location of the point in the source program text where execution is currently at. The first line contains the name of the source file, the start and end lines where the literal can be found, the substring to search for between those lines and the number of substrings to locate. This information for locating the point on the source file is not shown when executing the source-level debugger from the Ciao `emacs` mode.

Ports can be "unleashed" by calling the `leash/1` predicate omiting that port in the argument. This means that the debugger will stop but user interaction is not possible for an unleashed port.

Obviously, the ? prompt will not be shown in such messages, since the user has specified that no interaction is desired at this point.

6.6 Options available during debugging

This section describes the particular options that are available when the debugger prompts after printing out a debugging message. All the options are one letter mnemonics, some of which can be optionally followed by a decimal integer. They are read from the terminal with any blanks being completely ignored up to the next terminator (carriage-return, line-feed, or escape). Some options only actually require the terminator; e.g., the creep option, only requires ⟨RET⟩.

The only option which really needs to be remembered is 'h' (followed by ⟨RET⟩). This provides help in the form of the following list of available options.

```
<cr>   creep            c       creep
 l     leap             s       skip
 r     retry            r <i>   retry i
 f     fail             f <i>   fail i
 d     display          p       print
 w     write
 g     ancestors        g <n>   ancestors n
 n     nodebug          =       debugging
 +     spy this         -       nospy this
 a     abort
 @     command          u       unify
 <     reset printdepth < <n>   set printdepth
 ^     reset subterm    ^ <n>   set subterm
 ?     help             h       help
```

- `c` (*creep*)

  causes the debugger to single-step to the very next port and print a message. Then if the port is leashed the user is prompted for further interaction. Otherwise it continues creeping. If leashing is off, creep is the same as leap (see below) except that a complete trace is printed on the terminal.

- `l` (*leap*)

  causes the interpreter to resume running the program, only stopping when a spy-point or breakpoint is reached (or when the program terminates). Leaping can thus be used to follow the execution at a higher level than exhaustive tracing. All that is needed to do is to set spy-points and breakpoints on an evenly spread set of pertinent predicates or lines, and then follow the control flow through these by leaping from one to the other.

- `s` (*skip*)

  is only valid for Call and Redo ports, if it is issued in Exit or Fail ports it is equivalent to creep. It skips over the entire execution of the predicate. That is, no message will be seen until control comes back to this predicate (at either the Exit port or the Fail port). Skip is particularly useful while creeping since it guarantees that control will be returned after the (possibly complex) execution within the box. With skip then no message at all will appear until control returns to the Exit port or Fail port corresponding to this Call port or Redo port. This includes calls to predicates with spy-points and breakpoints set: they will be masked out during the skip. There is a way of overriding this: the `t` option after a ⟨^C⟩ interrupt will disable the masking. Normally, however, this masking is just what is required!

- `r` (*retry*)

  can be used at any of the four ports (although at the Call port it has no effect). It transfers control back to the Call port of the box. This allows restarting an invocation when, for example, it has left the programmer with some weird result. The state of execution is exactly the same as in the original call (unless the invocation has performed side effects, which will not be undone). When a retry is performed the invocation counter is reset so that counting will continue from the current invocation number regardless of what happened before the retry. This is in accord with the fact that execution has, in operational terms, returned to the state before anything else was called.

  If an integer is supplied after the retry command, then this is taken as specifying an invocation number and the system tries to get to the Call port, not of the current box, but of the invocation box specified. It does this by continuously failing until it reaches the right place. Unfortunately this process cannot be guaranteed: it may be the case that the invocation the programmer is looking for has been cut out of the search space by cuts in the program. In this case the system fails to the latest surviving Call port before the correct one.
- `f` (*fail*)

  can be used at any of the four ports (although at the Fail port it has no effect). It transfers control to the Fail port of the box, forcing the invocation to fail prematurely. If an integer is supplied after the command, then this is taken as specifying an invocation number and the system tries to get to the Fail port of the invocation box specified. It does this by continuously failing until it reaches the right place. Unfortunately, as before, this process cannot be guaranteed.
- `d` (*display*)

  displays the current goal using `display/1`. See `w` below.
- `p` (*print*)

  re-prints the current goal using `print/1`. Nested structures will be printed to the specified *printdepth* (see below).
- `w` (*write*)

  writes the current goal on the terminal using `write/1`.
- `g` (*ancestors*)

  provides a list of ancestors to the current goal, i.e., all goals that are hierarchically above the current goal in the calling sequence. It is always possible to jump to any goal in the ancestor list (by using retry, etc.). If an integer `n` is supplied, then only `n` ancestors will be printed. That is to say, the last `n` ancestors will be printed counting back from the current goal. Each entry in the list is preceded by the invocation number followed by the depth number (as would be given in a trace message).
- `n` (*nodebug*)

  switches the debugger off. Note that this is the correct way to switch debugging off at a trace point. The `@` option cannot be used because it always returns to the debugger.
- `=` (*debugging*)

  outputs information concerning the status of the current debugging session.
- `+` *spy*

  sets a spy-point on the current goal.
- `-` (*nospy*)

  removes the spy-point from the current goal.
- `a` (*abort*)

  causes an abort of the current execution. All the execution states built so far are destroyed and the system is put right back at the top-level of the interpreter. (This is the same as the built-in predicate `abort/0`.)

- `@` (*command*)

  allows calling arbitrary goals. The initial message `| ?-` will be output on the terminal, and a command is then read from the terminal and executed as if it was at top-level.
- `u` (*unify*()

  is available at the Call port and gives the option of providing a solution to the goal from the terminal rather than executing the goal. This is convenient, e.g., for providing a "stub" for a predicate that has not yet been written. A prompt `| :` will be output on the terminal, and the solution is then read from the terminal and unified with the goal.
- `<` (*printdepth*)

  sets a limit for the subterm nesting level that is printed in messages. While in the debugger, a printdepth is in effect for limiting the subterm nesting level when printing the current goal. When displaying or writing the current goal, all nesting levels are shown. The limit is initially 10. This command, without arguments, resets the limit to 10. With an argument of `n` the limit is set to `n`.
- `^` (*subterm*)

  sets the subterm to be printed in messages. While at a particular port, a current subterm of the current goal is maintained. It is the current subterm which is displayed, printed, or written when prompting for a debugger command. Used in combination with the printdepth, this provides a means for navigating in the current goal for focusing on the part which is of interest. The current subterm is set to the current goal when arriving at a new port. This command, without arguments, resets the current subterm to the current goal. With an argument of `n` (greater than 0 and less or equal to the number of subterms of the current subterm), the current subterm is replaced by its `n`'th subterm. With an argument of `0`, the current subterm is replaced by its parent term.
- `?` or `h` (*help*)

  displays the table of options given above.

6.7 Calling predicates that are not exported by a module

The Ciao module system does not allow calling predicates which are not exported during debugging. However, as an aid during debugging, this is allowed (only from the top-level and for modules which are in debug mode or source-level debug mode) using the `call_in_module/2` predicate.

Note that this does not affect analysis or optimization issues, since it only works on modules which are loaded in debug mode or source-level debug mode, i.e. unoptimized.

7 Predicates controlling the interactive debugger

Author(s): A. Ciepielewski, M. Carlsson, T. Chikayama, K. Shen, D. Cabeza, M. Rodriguez.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#185 (2002/2/4, 18:45:52 CET)

This library implements predicates which are normally used in the interactive top-level shell to debug programs. A subset of them are available in the embeddable debugger.

7.1 Usage and interface (debugger)

- **Library usage:**
  `:- use_module(library(debugger)).`
- **Exports:**
  - *Predicates:*
    `debug_module/1`, `nodebug_module/1`, `debug_module_source/1`, `debug/0`, `nodebug/0`, `trace/0`, `notrace/0`, `spy/1`, `nospy/1`, `nospyall/0`, `breakpt/6`, `nobreakpt/6`, `nobreakall/0`, `list_breakpt/0`, `debugging/0`, `leash/1`, `maxdepth/1`, `call_in_module/2`.
- **Other modules used:**
  - *System library modules:*
    `debugger/debugger_lib`, `format`, `ttyout`, `read`, `system`, `write`, `aggregates`, `sort`.

7.2 Documentation on exports (debugger)

debug_module/1: PREDICATE

Usage: `debug_module(Module)`

- *Description:* The debugger will take into acount module `Module` (assuming it is loaded in interpreted mode). When issuing this command at the toplevel shell, the compiler is instructed also to set to *interpret* the loading mode of files defining that module and also to mark it as 'modified' so that (re)loading this file or a main file that uses this module will force it to be reloaded for source-level debugging.
- *The following properties should hold at call time:*
  `Module` is an atom. (`basic_props:atm/1`)

nodebug_module/1: PREDICATE

Usage: `nodebug_module(Module)`

- *Description:* The debugger will not take into acount module `Module`. When issuing this command at the toplevel shell, the compiler is instructed also to set to *compile* the loading mode of files defining that module.
- *The following properties should hold at call time:*
  `Module` is an atom. (`basic_props:atm/1`)

debug_module_source/1: PREDICATE

Usage: `debug_module_source(Module)`

- *Description:* The debugger will take into acount module `Module` (assuming it is is loaded in source-level debug mode). When issuing this command at the toplevel shell, the compiler is instructed also to set to *interpret* the loading mode of files defining that module and also to mark it as 'modified' so that (re)loading this file or a main file that uses this module will force it to be reloaded for source-level debugging.
- *The following properties should hold at call time:*

  `Module` is an atom. (`basic_props:atm/1`)

debug/0: PREDICATE

Usage:

- *Description:* Switches the debugger on. The interpreter will stop at all ports of procedure boxes of spied predicates.

nodebug/0: PREDICATE

Usage:

- *Description:* Switches the debugger off. If there are any spy-points set then they will be kept but disabled.

trace/0: PREDICATE

Usage:

- *Description:* Start tracing, switching the debugger on if needed. The interpreter will stop at all leashed ports of procedure boxes of predicates either belonging to debugged modules or called from clauses of debugged modules. A message is printed at each stop point, expecting input from the user (write `h` to see the available options).

notrace/0: PREDICATE

Usage:

- *Description:* Equivalent to `nodebug/0`.

spy/1: PREDICATE

Usage: `spy(PredSpec)`

- *Description:* Set spy-points on predicates belonging to debugged modules and which match `PredSpec`, switching the debugger on if needed. This predicate is defined as a prefix operator by the toplevel.
- *The following properties should hold at call time:*

  `PredSpec` is a sequence of `multpredspecs`. (`basic_props:sequence/2`)

nospy/1: PREDICATE

Usage: `nospy(PredSpec)`

- *Description:* Remove spy-points on predicates belonging to debugged modules which match `PredSpec`. This predicate is defined as a prefix operator by the toplevel.
- *The following properties should hold at call time:*

  `PredSpec` is a sequence of `multpredspecs`. (`basic_props:sequence/2`)

nospyall/0: PREDICATE

Usage:

- *Description:* Remove all spy-points.

breakpt/6: PREDICATE

Usage: `breakpt(Pred,Src,Ln0,Ln1,Number,RealLine)`

- *Description:* Set a *breakpoint* in file `Src` between lines `Ln0` and `Ln1` at the literal corresponding to the `Number`'th occurence of (predicate) name `Pred`. The pair `Ln0-Ln1` uniquely identifies a program clause and must correspond to the start and end line numbers for the clause. The rest of the arguments provide enough information to be able to locate the exact literal that the `RealLine` line refers to. This is normally not issued by users but rather by the `emacs` mode, which automatically computes the different argument after selecting a point in the source file.
- *The following properties should hold at call time:*

  `Pred` is an atom. (`basic_props:atm/1`)

  `Src` is a source name. (`streams_basic:sourcename/1`)

  `Ln0` is an integer. (`basic_props:int/1`)

  `Ln1` is an integer. (`basic_props:int/1`)

  `Number` is an integer. (`basic_props:int/1`)

  `RealLine` is an integer. (`basic_props:int/1`)

nobreakpt/6: PREDICATE

Usage: `nobreakpt(Pred,Src,Ln0,Ln1,Number,RealLine)`

- *Description:* Remove a breakpoint in file `Src` between lines `Ln0` and `Ln1` at the `Number`'th occurence of (predicate) name `Pred` (see `breakpt/6`). Also normally used from de `emacs` mode.
- *The following properties should hold at call time:*

  `Pred` is an atom. (`basic_props:atm/1`)

  `Src` is a source name. (`streams_basic:sourcename/1`)

  `Ln0` is an integer. (`basic_props:int/1`)

  `Ln1` is an integer. (`basic_props:int/1`)

  `Number` is an integer. (`basic_props:int/1`)

  `RealLine` is an integer. (`basic_props:int/1`)

nobreakall/0: PREDICATE

Usage:

- *Description:* Remove all breakpoints.

list_breakpt/0: PREDICATE

Usage:

- *Description:* Prints out the location of all breakpoints. The location of the breakpoints is showed usual by referring to the source file, the lines between which the predicate can be found, the predicate name and the number of ocurrence of the predicate name of the literal.

debugging/0: PREDICATE

Usage:

- *Description:* Display debugger state.

leash/1: PREDICATE

Usage: `leash(Ports)`

- *Description:* Leash on ports `Ports`, some of `call`, `exit`, `redo`, `fail`. By default, all ports are on leash.
- *The following properties should hold at call time:*

  `Ports` is a list of `ports`. (`basic_props:list/2`)

maxdepth/1: PREDICATE

Usage: `maxdepth(MaxDepth)`

- *Description:* Set maximum invocation depth in debugging to `MaxDepth`. Calls to compiled predicates are not included in the computation of the depth.
- *The following properties should hold at call time:*

  `MaxDepth` is an integer. (`basic_props:int/1`)

call_in_module/2: PREDICATE

Usage: `call_in_module(Module,Predicate)`

- *Description:* Calls predicate `Predicate` belonging to module `Module`, even if that module does not export the predicate. This only works for modules which are in debug (interpreted) mode (i.e., they are not optimized).
- *The following properties should hold at call time:*

  `Module` is an atom. (`basic_props:atm/1`)

  `Predicate` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

7.3 Documentation on internals (debugger)

multpredspec/1: PROPERTY

A property, defined as follows:

```
multpredspec(Mod:Spec) :-
        atm(Mod),
        multpredspec(Spec).
multpredspec(Name/Low-High) :-
        atm(Name),
        int(Low),
        int(High).
multpredspec(Name/(Low-High)) :-
        atm(Name),
        int(Low),
        int(High).
multpredspec(Name/Arity) :-
        atm(Name),
        int(Arity).
multpredspec(Name) :-
        atm(Name).
```

7.4 Known bugs and planned improvements (debugger)

- Add an option to the emacs menu to automatically select all modules in a project.
- Consider the possibility to show debugging messages directly in the source code emacs buffer.

8 The script interpreter

Author(s): Daniel Cabeza, Manuel Hermenegildo.

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`ciao-shell` is the Ciao script interpreter. It can be used to write *Prolog shell scripts* (see [Her96,CHV96b]), that is, executable files containing source code, which are compiled on demand.

Writing Prolog scripts can sometimes be advantageous with respect to creating binary executables for small- to medium-sized programs that are modified often and perform relatively simple tasks. The advantage is that no explicit compilation is necessary, and thus changes and updates to the program imply only editing the source file. The disadvantage is that startup of the script (the first time after it is modified) is slower than for an application that has been compiled previously.

An area of application is, for example, writing *CGI executables*: the slow speed of the network connection in comparison with that of executing a program makes program execution speed less important and has made scripting languages very popular for writing these applications. Logic languages are, a priori, excellent candidates to be used as scripting languages. For example, the built-in grammars and databases can sometimes greatly simplify many typical script-based applications.

8.1 How it works

Essentially, `ciao-shell` is a smaller version of the Ciao top-level, which starts by loading the file given to it as the first argument and then starts execution at `main/1` (the argument is instantiated to a list containing the command line options, in the usual way). Note that the Prolog script cannot have a `module` declaration for this to work. While loading the file, `ciao-shell` changes the prolog flag `quiet` so that no informational or warning messages are printed (error messages will be reported to `user_error`, however). The operation of `ciao-shell` in Unix-like systems is based in a special compiler feature: when the first character of a file is '`#`', the compiler skips the first lines until an empty line is found. In Windows, its use is as easy as naming the file with a `.pls` extension, which will launch `ciao-shell` appropriately.

For example, in a Linux/Unix system, assume a file called `hello` contains the following program:

```
#!/bin/sh
exec ciao-shell $0 "$@" # -*- mode: ciao; -*-

main(_) :-
     write('Hello world'), nl.
```

Then, the file `hello` can be *run* by simply making it executable and invoking it from the command line:

```
/herme@clip:/tmp
[86]> chmod +x hello

/herme@clip:/tmp
[87]> hello
Hello world
```

The line:

```
#!/bin/sh
```

invokes the `/bin/sh` shell which will interpret the following line:

```
exec ciao-shell $0 "$@" # -*- mode: ciao; -*-
```

and invoke `ciao-shell`, instructing it to read this same file (`$0`), passing it the rest of the arguments to `hello` as arguments to the prolog program. The second part of the line `# -*- mode: ciao; -*-` is simply a comment which is seen by `emacs` and instructs it to edit this file in Ciao mode (this is needed because these script files typically do not have a `.pl` ending). When `ciao-shell` starts, if it is the first time, it compiles the program (skipping the first lines, as explained above), or else at successive runs loads the `.po` object file, and then calls `main/1`.

Note that the process of creating Prolog scripts is made very simple by the Ciao emacs mode, which automatically inserts the header and makes the file executable (See Chapter 10 [Using Ciao inside GNU emacs], page 63).

8.2 Command line arguments in scripts

The following example illustrates the use of command-line arguments in scripts. Assume that a file called `say` contains the following lines:

```
#!/bin/sh
exec ciao-shell $0 "$@" # -*- mode: ciao; -*-

main(Argv) :-
     write_list(Argv), nl.

write_list([]).
write_list([Arg|Args]) :-
     write(Arg),
     write(' '),
     write_list(Args).
```

An example of use is:

```
/herme@clip:/tmp
[91]> say hello dolly
hello dolly
```

9 Customizing library paths and path aliases

Author(s): D.Cabeza.

This library provides means for customizing, from environment variables, the libraries and path aliases known by an executable. Many applications of Ciao, including `ciaoc`, `ciaosh`, and `ciao-shell` make use of this library. Note that if an executable is created dynamic, it will try to load its components at startup, before the procedures of this module can be invoked, so in this case all the components should be in standard locations.

9.1 Usage and interface (`libpaths`)

- **Library usage:**
  `:- use_module(library(libpaths)).`
- **Exports:**
  - *Predicates:*
    `get_alias_path/0`.
  - *Multifiles:*
    `file_search_path/2`, `library_directory/1`.
- **Other modules used:**
  - *System library modules:*
    `system`, `lists`.

9.2 Documentation on exports (`libpaths`)

get_alias_path/0: PREDICATE

`get_alias_path`

Consult the environment variable 'CIAOALIASPATH' and add facts to predicates `library_directory/1` and `file_search_path/2` to define new library paths and path aliases. The format of 'CIAOALIASPATH' is a sequence of paths or alias assignments separated by colons, an alias assignment is the name of the alias, an '=' and the path represented by that alias (no blanks allowed). For example, given

```
CIAOALIASPATH=/home/bardo/ciao:contrib=/usr/local/lib/ciao
```

the predicate will define /home/bardo/ciao as a library path and /usr/local/lib/ciao as the path represented by 'contrib'.

9.3 Documentation on multifiles (`libpaths`)

file_search_path/2: PREDICATE

See Chapter 21 [Basic file/stream handling], page 117.

The predicate is *multifile*.

The predicate is of type *dynamic*.

library_directory/1: PREDICATE

See Chapter 21 [Basic file/stream handling], page 117.

The predicate is *multifile*.

The predicate is of type *dynamic*.

10 Using Ciao inside GNU emacs

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The Ciao/Prolog emacs interface (or *mode* in `emacs` terms) provides a rich, integrated user interface to the Ciao *program development environment* components, including the `ciaosh` interactive top level and the `ciaopp` preprocessor. While most features of the Ciao development environment are available from the command line of the preprocessor and the top-level shell, using Ciao inside `emacs` is highly recommended. The facilities that this mode provides include:

- *Syntax highlighting* and syntax coloring, *auto-indentation*, *auto-fill*, etc. of code. This includes the assertions used by the preprocessor and the documentation strings used by the Ciao auto-documenter, `lpdoc`.
- Providing automatic access to on-line help for all predicates by accessing the Ciao system manuals in `info` format.
- Starting and communicating with `ciaopp`, the *Ciao preprocessor*, running in its own sub-shell. This allows easily performing certain kinds of *static checks* (useful for finding errors in programs before running them), program analysis tasks, and *program transformations* on source programs.
- Starting and communicating with the *Ciao top-level*, running in its own sub-shell. This facilitates loading programs, checking the *syntax* of programs (and of *assertions* within programs), marking and unmarking modules for interactive debugging, *tracing the source code* during debugging, making stand-alone executables, compiling modules to dynamically linkable Prolog objects, compiling modules to active objects, etc.
- Syntax highlighting and coloring of the error and warning messages produced by the top level, preprocessor, or any other tool using the same message format (such as the `lpdoc` auto-documenter), and *locating automatically the points in the source files where such errors occur*.
- Performing automatic *version control* and keeping a *changelog* of individual files or whole applications. This is done by automatically including changelog entries in source files, which can then be processed by the `lpdoc` auto-documenter.

This chapter explains how to use the Ciao/Prolog `emacs` interface and how to set up your `emacs` environment for correct operation. The Ciao `emacs` interface can also be used to work with other Prolog or CLP systems.

10.1 Conventions for writing Ciao programs under Emacs

This is particularly important for the source-level debugger and the syntax coloring capabilities. This is due to the fact that it would be unrealistic to write a complete Prolog parser in Emacs lisp. These conventions are the following, in order of importance:

- Clauses should begin on the first column (this is used to recognize the beginning of a clause).
- C style comments should not be used in a clause, but can be used outside any clause.

The following are suggestions which are not strictly necessary but which can improve operation:

- Body literals should be indented, and there should be not more than one literal per line. This allows more precision in the location of program points during source-level debugging, i.e., when marking breakpoints and during line tracing.

%s start *small* comments (indented to the right). For syntax highlighting to be performed font-lock must be available and not disabled (the Ciao mode enables it but it may be disabled elsewhere in, e.g., the `.emacs` file).

10.2 Checking the installation

Typically, a complete pre-installation of the Ciao/Prolog `emacs` interface is completed during Ciao installation. To check that installation was done and sucessful, open a file with a `.pl` ending. You should see that `emacs` enters Ciao/Prolog mode: the mode is identified in the status bar below the buffer and, if the emacs menu bar is enabled, you should see the Ciao/Prolog menus. You should be able from the menu-bar, for example, to go to the Ciao manuals in the info or load the `.pl` file that you just opened into a ciao top level.

If things don't work properly, see the section Section 10.21 [Installation of the Ciao/Prolog emacs interface], page 77 later in this chapter.

10.3 Functionality and associated key sequences (bindings)

The following sections summarize the capabilities of the Ciao/Prolog emacs interface and the (default) *key sequences* used to access those capabilities. Most of these functions are accessible also from the menu bar.

10.4 Syntax coloring and syntax-based editing

Syntax-based coloring is provided automatically when opening Ciao/Prolog files. The mode should be set to Ciao/Prolog and the Ciao mode menus should appear on the menu bar. Limited syntax-based indentation is also provided:

⟨TAB⟩ Indent current line as Ciao/Prolog code. With argument, indent any additional lines of the same clause rigidly along with this one.

10.5 Getting on-line help

The following commands are useful for getting on-line help. This is done by accessing the `info` version of the Ciao manuals or the `emacs` built-in help strings. Note also that the `info` standard `search` command (generally bound to ⟨s⟩) can be used inside `info` buffers to search for a given string.

⟨^C⟩ ⟨TAB⟩ Find help for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Opens a (hopefully) relevant part of the Ciao manuals in `info` mode. Requires that the Ciao manuals in `info` format be installed and accessible to `emacs` (i.e., they should appear somewhere in the info directory when typing `M-x info`). It also requires `word-help.el`, which is provided with Ciao. Refer to the installation instructions if this is not the case.

⟨^C⟩ ⟨/⟩ Find a completion for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Uses for completion the contents of the indices of the Ciao manuals. Same requirements as for finding help for the symbol.

⟨^C⟩ ⟨^M⟩ Go to the part of the info directory containing the Ciao manuals.

⟨^H⟩ ⟨m⟩ Show a short description of the Ciao/Prolog emacs mode, including all key bindings.

10.6 Loading and compiling programs

These commands allow *loading programs*, *creating executables*, etc. by issuing the appropriate commands to a Ciao/Prolog top level shell, running in its own buffer as a subprocess. See Chapter 5 [The interactive top-level shell], page 37 for details. The following commands implement the communication with the Ciao/Prolog top level:

⟨^C⟩ ⟨t⟩ Ensure that an inferior Ciao/Prolog top-level process is running.

This opens a top-level window (if one did not exist already) where queries can be input directly as in any normal Prolog top level. Programs can be loaded into this top level by typing the corresponding commands in this window (such as use_module, etc.), or, more typically, by opening the file to be loaded in an emacs window (where it can be edited) and issuing a load command (such as C-c l or C-c L) directly from there (see the loading commands of this mode and their bindings).

Note that many useful commands (e.g., to repeat and edit previous commands, interrupt jobs, locate errors, automatic completions, etc.) are available in this top-level window (see Section 10.7 [Commands available in toplevel and preprocessor buffers], page 66).

Often, it is not necessary to use this function since execution of any of the other functions related to the top level (e.g., loading buffers into the top level) ensures that a top level is started (starting one if required).

⟨^C⟩ ⟨l⟩ Load the current buffer (and any auxiliary files it may use) into the top level.

The type of compilation performed (*compiling* or *interpreting*) is selected automatically depending on whether the buffer has been marked for debugging or not – see below. In case you try to load a file while in the middle of the debugging process the debugger is first aborted and then the buffer is loaded. Also, if there is a defined query, the user is asked whether it should be called.

⟨^C⟩ ⟨x⟩ Make an executable from the code in the current buffer. The buffer must contain a `main/0` or `main/1` predicate. Note that compiler options can be set to determine whether the libraries and auxiliary files used by the executable will be statically linked, dynamically linked, auto-loaded, etc.

⟨^C⟩ ⟨o⟩ Make a Prolog object (.po) file from the code in the current buffer. This is very useful during debugging or program development, when only one or a few files of a large application are modified. If the application executable is dynamically linked, i.e., the component .po files are loaded dynamically during startup of the application, then this command can be used to recompile only the file or files which have changed, and the correct version will be loaded dynamically the next time the application is started. However, note that this only works if the inter-module interfaces have not changed. A safer, but possibly slower way is to generate the executable again, letting the Ciao compiler, which is inherently incremental, determine what needs to be recompiled.

⟨^C⟩ ⟨a⟩ Make an active module executable from the code in the current buffer. An active module is a remote procedure call server (see the `activemod` library documentation for details).

⟨^C⟩ ⟨s⟩ Set the current buffer as the principal file in a multiple module programming environment.

⟨^C⟩ ⟨L⟩ Load the module designated as *main module* (and all related files that it uses) into the top level. If no main module is defined it will load the current buffer.

The type of compilation performed (*compiling* or *interpreting*) is selected automatically depending on whether the buffer has been marked for debugging or not – see

below. In case you try to load a file while in the middle of the debugging process the debugger is first aborted and then the buffer is loaded. Also, if there is a defined query, the user is asked whether is should be called.

⟨^C⟩ ⟨q⟩ Set a default query. This may be useful specially during debugging sessions. However, as mentioned elsewhere, note that commands that repeat previous queries are also available.

This query can be recalled at any time using C-c Q. It is also possible to set things up so that this query will be issued automatically any time a program is (re)loaded. The functionality is available in the major mode (i.e., from a buffer containing a source file) and in the inferior mode (i.e., from the buffer running the top-level shell). When called from the major mode (i.e., from window containing a source file) then the user is prompted in the minibuffer for the query. When called from the inferior mode (i.e., from a top-level window) then the query on the current line, following the Ciao prompt, is taken as the default query.

To clear the default query use M-x ciao-clear-query or simply set it to an empty query: i.e., in a source buffer select C-c q and enter an empty query. In an inferior mode simply select C-c q on a line that contains only the system prompt.

⟨^C⟩ ⟨Q⟩ Issue predefined query.

10.7 Commands available in toplevel and preprocessor buffers

The interactive top level and the preprocessor both are typically run in an iteractive buffer, in which it is possible to communicate with them in the same way as if they had been started from a standard shell. These interactive buffers run in the so-called *Ciao/Prolog inferior mode*. This is a particular version of the standard emacs shell package (comint) and thus all the commands typically available when running shells inside emacs also work in these buffers. In addition, many of the commands and key bindings available in buffers containing Ciao source code are also available in these interactive buffers, when applicable. The Ciao/Prolog-specific commands available include:

⟨^C⟩ ⟨TAB⟩ Find help for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Opens a (hopefully) relevant part of the Ciao manuals in `info` mode. Requires that the Ciao manuals in `info` format be installed and accessible to `emacs` (i.e., they should appear somewhere in the info directory when typing `M-x info`). It also requires `word-help.el`, which is provided with Ciao. Refer to the installation instructions if this is not the case.

⟨^C⟩ ⟨/⟩ Find a completion for the symbol (e.g., predicate, directive, declaration, type, etc.) that is currently under the cursor. Uses for completion the contents of the indices of the Ciao manuals. Same requirements as for finding help for the symbol.

⟨^C⟩ ⟨`⟩ Go to the location in the source file containing the next error reported by the last Ciao/Prolog subprocess (preprocessor or toplevel) which was run.

⟨^C⟩ ⟨e⟩ Remove the error mark in a buffer.

⟨^C⟩ ⟨q⟩ Set a default query. This may be useful specially during debugging sessions. However, as mentioned elsewhere, note that commands that repeat previous queries are also available.

This query can be recalled at any time using C-c Q. It is also possible to set things up so that this query will be issued automatically any time a program is (re)loaded. The functionality is available in the major mode (i.e., from a buffer containing a source file) and in the inferior mode (i.e., from the buffer running the top-level shell). When called from the major mode (i.e., from window containing a source file) then

the user is prompted in the minibuffer for the query. When called from the inferior mode (i.e., from a top-level window) then the query on the current line, following the Ciao prompt, is taken as the default query.

To clear the default query use M-x ciao-clear-query or simply set it to an empty query: i.e., in a source buffer select C-c q and enter an empty query. In an inferior mode simply select C-c q on a line that contains only the system prompt.

⟨^C⟩ ⟨Q⟩ Issue predefined query.

The following are some of the commands from the comint shell package which may be specially useful (type `C-h m` while in a Ciao interactive buffer for a complete list of commands):

⟨M-p⟩ Cycle backwards through input history.

⟨M-n⟩ Cycle forwards through input history.

⟨M-r⟩ Search backwards through input history for match for REGEXP. (Previous history elements are earlier commands.) With prefix argument N, search for Nth previous match. If N is negative, find the next or Nth next match.

⟨TAB⟩ Dynamically find completion of the item at point. Note that this completion command refers generally to filenames (rather than, e.g., predicate names, as in the previous functions).

⟨M-?⟩ List all (filename) completions of the item at point.

⟨RET⟩ Return at any point of the a line at the end of a buffer sends that line as input. Return not at end copies the rest of the current line to the end of the buffer and sends it as input.

⟨^D⟩ Delete ARG characters forward or send an EOF to subprocess. Sends an EOF only if point is at the end of the buffer and there is no input.

⟨^C⟩ ⟨^U⟩ Kill all text from last stuff output by interpreter to point.

⟨^C⟩ ⟨^W⟩ Kill characters backward until encountering the end of a word. With argument, do this that many times.

⟨^C⟩ ⟨^C⟩ Interrupt the current subjob. This command also kills the pending input between the process-mark and point.

⟨^C⟩ ⟨^Z⟩ Stop the current subjob. This command also kills the pending input between the process-mark and point.

WARNING: if there is no current subjob, you can end up suspending the top-level process running in the buffer. If you accidentally do this, use M-x comint-continue-subjob to resume the process. (This is not a problem with most shells, since they ignore this signal.)

⟨^C⟩ ⟨^\⟩ Send quit signal to the current subjob. This command also kills the pending input between the process-mark and point.

10.8 Locating errors and checking the syntax of assertions

These commands allow locating quickly the point in the source code corresponding to errors flagged by the compiler or preprocessor as well as performing several syntactic checks of assertions:

⟨^C⟩ ⟨`⟩ Go to the location in the source file containing the next error reported by the last Ciao/Prolog subprocess (preprocessor or toplevel) which was run.

⟨^C⟩ ⟨e⟩ Remove the error mark in a buffer.

⟨^C⟩ ⟨E⟩ Check the *syntax* of the code and assertions in the current buffer, as well as imports and exports. This uses the standard top level (i.e., does not call the preprocessor and thus does not require the preprocessor to be installed). Note that full (semantic) assertion checking must be done with the preprocessor.

10.9 Commands which help typing in programs

The following commands are intended to help in the process of writing programs:

⟨^C⟩ ⟨l⟩ ⟨S⟩ Insert a (Unix) header at the top of the current buffer so that the ciao script interpreter will be called on this file if *run* from the command line. It also makes the file "executable" (e.g., '`chmod +x <file>`' in Unix). See Chapter 8 [The script interpreter], page 59 for details.

10.10 Debugging programs

These commands allow marking modules for *debugging* by issuing the appropiate commands to a Ciao/Prolog top level shell, running in its own buffer as a subprocess. There are two differents types of debugging: traditional Prolog debugging (using the byrd-box model and spy-points) and *source-level debugging* (same as traditional debugging plus source tracing and breakpoints). In order to use *breakpoints*, source debugging must be on. The following commands implement comunication with the Ciao/Prolog top level:

⟨^C⟩ ⟨d⟩ Debug (or stop debugging) buffer source. This is a shortcut which is particularly useful when using the source debugger on a single module. It corresponds to several lower-level actions. Those lower-level actions depend on how the module was selected for debugging. In case the module was not marked for source-level debugging, it marks the module corresponding to the current buffer for source-level debugging, reloads it to make sure that it is loaded in the correct way for debugging (same as C-c l), and sets the debugger in trace mode (i.e., issues the `trace.` command to the top-level shell). Conversely, if the module was already marked for source-level debugging then it will take the opposite actions, i.e., it unmarks the module for source-level debugging, reloads it, and sets the debugger to non-debug mode.

⟨^C⟩ ⟨m⟩ Mark, or unmkark, the current buffer for debugging (traditional debugging or source debugging). Note that if the buffer has already been loaded while it was unmarked for debugging (and has therefore been loaded in "compile" mode) it has to be loaded again. The minibuffer shows how the module is loaded now and allows selecting another mode for it. There are three posibilities: N for no debug, S for source debug and D for traditional debug.

⟨^C⟩ ⟨M-m⟩ Visits all Ciao/Prolog files which are currently open in a buffer allowing selecting for each of them whether to debug them or not and the type of debugging performed. When working on a multiple module program, it is possible to have many modules open at a time. In this case, you will navigate through all open Ciao/Prolog files and select the debug mode for each of them (same as doing C-c m for each).

⟨^C⟩ ⟨S⟩ ⟨b⟩ Set a breakpoint on the current literal (goal). This can be done at any time (while debugging or not). The cursor must be *on the predicate symbol of the literal.* Breakpoints are only useful when using source-level debugging.

⟨^C⟩ ⟨S⟩ ⟨v⟩ Remove a breakpoint from the current literal (goal). This can be done at any time (while debugging or not). The cursor must be *on the predicate symbol of the literal.*

⟨^C⟩ ⟨S⟩ ⟨n⟩ Remove all breakpoints. This can be done at any time (while debugging or not).

⟨^C⟩ ⟨S⟩ ⟨l⟩ Redisplay breakpoints in all Ciao buffers. This ensures that the marks in the source files and the Ciao/Prolog toplevel are synchronized.

⟨^C⟩ ⟨S⟩ ⟨r⟩ Remove breakpoints color in all Ciao/Prolog files.

⟨^C⟩ ⟨S⟩ ⟨t⟩ Set the debugger to the trace state. In this state, the program is executed step by step.

⟨^C⟩ ⟨S⟩ ⟨d⟩ Set the debugger to the debug state. In this state, the program will only stop in breakpoints and spypoints. Breakpoints are specially supported in `emacs` and using source debug.

⟨^C⟩ ⟨r⟩ Load the current region (between the cursor and a previous mark) into the top level. Since loading a region of a file is typically done for debugging and/or testing purposes, this command always loads the region in debugging mode (interpreted).

⟨^C⟩ ⟨p⟩ Load the predicate around the cursor into the top level. Since loading a single predicate is typically done for debugging and/or testing purposes, this command always loads the predicate in debugging mode (interpreted).

10.11 Preprocessing programs

These commands allow *preprocessing programs* with `ciaopp`, the *Ciao preprocessor*.

`ciaopp` is the precompiler of the Ciao Prolog development environment. `ciaopp` can perform a number of program debugging, analysis and source-to-source transformation tasks on (Ciao) Prolog programs. These tasks include:

- *Inference of properties* of the predicates and literals of the progam, including *types*, *modes* and other *variable instantiation* properties, *non-failure*, *determinacy*, bounds on *computational cost*, bounds on *sizes of terms* in the program, etc.
- Certain kinds of *static debugging*, finding errors before running the program. This includes checking the ways in which programs call the system library predicates and also *checking the assertions* present in the program or in other modules used by the program. Such assertions essentially represent partial *specifications* of the program.
- Several kinds of source to source *program transformations* such as *program specialization*, *program parallelization* (including *granularity control*), inclusion of *run-time tests* for assertions which cannot be checked completely at compile-time, etc.

The information generated by analysis, the assertions in the system libraries, and the assertions optionally included in user programs as specifications are all written in the same *assertion language*, which is in turn also used by the Ciao system documentation generator, `lpdoc`.

`ciaopp` is distributed under the GNU general public license.

See the preprocessor manual for details. The following commands implement the communication with the Ciao preprocessor:

⟨^C⟩ ⟨M⟩ Preprocess the buffer, selecting options. Instructs the preprocessor to load the current buffer and start an interactive dialog in which the different options available in the preprocessor can be set.

⟨^C⟩ ⟨P⟩ Preprocess the buffer, using the previously selected options. If no options were set previously, then the preprocessor defaults are used.

⟨^C⟩ ⟨T⟩ Uses the preprocessor to perform compile-time checking of types and modes (pp-typesfd and shfr analyses).

⟨^C⟩ ⟨^P⟩ Make ciaopp output only predicate-level analysis information.

⟨^C⟩ ⟨^F⟩ Make ciaopp output both literal- and predicate-level analysis information.

⟨^C⟩ ⟨^X⟩ Make ciaopp output no analysis information.

⟨^C⟩ ⟨^V⟩ Show last output file produced by Ciao preprocessor. The preprocessor works by producing a file which is a transformed and/or adorned (with assertions) version of the input file. This command is often used after running the preprocessor in order to visit the output file and see the results from running the preprocessor.

⟨^C⟩ ⟨V⟩ Preprocess the buffer, using the previously selected (or default) options, waits for preprocessing to finish and displays the preprocessor output (leaving the cursor at the same point if already on a preprocessor output file). This allows running the preprocessor over and over and watching the output while modifying the source code.

⟨^C⟩ ⟨^R⟩ Ensure that an inferior Ciao preprocessor process is running.

This opens a preprocessor top-level window (if one did not exist already) where preprocessing commands and preprocessing menu options can be input directly. Programs can be preprocessed by typing commands in this window, or, more typically, by opening the file to be preprocessed in an emacs window (where it can be edited) and issuing a command (such as C-c M or C-c P) directly from there (see the preprocessing commands of this mode and their bindings).

Note that many useful commands (e.g., to repeat and edit previous commands, interrupt jobs, locate errors, automatic completions, etc.) are available in this top-level window (see Section 10.7 [Commands available in toplevel and preprocessor buffers], page 66).

Often, it is not necessary to use this function since execution of any of the other functions related to the top level (e.g., loading buffers into the top level) ensures that a top level is started (starting one if required).

10.12 Version control

The following commands can be used to carry out a simple but effective form of version control by keeping a log of changes on a file or a group of related files. Interestingly, this log is kept in a format that is understood by `lpdoc`, the Ciao documenter [Her99]. As a result, if these version comments are present, then `lpdoc` will be able to automatically assign up to date version numbers to the manuals that it generates. This way it is always possible to identify to which version of the software a manual corresponds. Also, `lpdoc` can create automatically sections describing the changes made since previous versions, which are extracted from the comments in the changelog entries.

The main effect of these commands is to automatically associate the following information to a set of changes performed in the file and/or in a set of related files:

- a *version number* (such as, e.g., `1.2`, where `1` is the major version number and `2` is the minor version number),
- a patch number (such as, e.g., the `4` in `1.2#4`),
- a time stamp (such as, e.g., `1998/12/14,17:20*28+MET`),
- the author of the change, and
- a comment explaining the change.

The version numbering used can be local to a single file or common to a number of related files. A simple version numbering policy is implemented: when a relevant change is made, the user typically inserts a changelog entry for it, using the appropriate command (or selecting the corresponding option when prompted while saving a file). This will cause the *patch number* for the file (or for the whole system that the file is part of) to be incremented automatically and the corresponding machine-readable comment to be inserted in the file. Major and minor version numbers can also be changed, but this is always invoked by hand (see below).

The changelog entry is written in the form of a `comment/2` declaration. As mentioned before, the advantage of using this kind of changelog entries is that these declarations can be processed by the `lpdoc` automatic documenter (see the `lpdoc` reference manual [Her99] or the `assertions` library documentation for more details on these declarations).

Whether the user is asked or not to introduce such changelog entries, and how the patch and version numbers should be increased is controlled by the presence in the file of a `comment/2` declaration of the type:

```
:- comment(version_maintenance,<type>).
```

(note that this requires including the `assertions` library in the source file). These declarations themselves are also typically introduced automatically when using this mode (see below).

The version maintenance mode can also be set alternatively by inserting a comment such as:

```
%% Local Variables:
%% mode: ciao
%% update-version-comments: "off"
%% End:
```

The lines above instruct emacs to put the buffer visiting the file in emacs Ciao/Prolog mode and to turn version maintenance off. Setting the version maintenance mode in this way has the disadvantage that `lpdoc`, the auto-documenter, and other related tools will not be aware of the type of version maintenance being performed (the lines above are comments for Prolog). However, this can be useful in fact for setting the *version maintenance mode for packages* and other files meant for inclusion in other files, since that way the settings will not affect the file in which the package is included.

The following commands implement the version control support:

⟨^X⟩ ⟨^S⟩ This is the standard `emacs` command that saves a buffer by writing the contents into the associated `.pl` file. However, in Ciao/Prolog mode this command can be set to ask the user before saving whether to introduce a changelog entry documenting the changes performed.

If the buffer does not already contain a comment specifying the type of version control to be performed, and before saving the buffer, the Ciao/Prolog mode prompts the user to choose among the following options:

⟨q⟩ Turn off prompting for the introduction of changelog entries for now. `emacs` will not ask again while the buffer is loaded, but it will ask again next time you load the buffer.

⟨n⟩ Turn off version control for this file. A version control comment such as:

```
:- comment(version_maintenance,off).
```

is added to the buffer and the file is saved. `emacs` will not perform any version control on this file until the line above is removed or modified (i.e., from now on C-x C-s simply saves the buffer).

⟨y⟩ Turn version control on for this file.

If ⟨y⟩ is selected, then the system prompts again regarding how and where the version and patch number information is to be maintained. The following options are available:

`on` All version control information will be contained within this file. When saving a buffer (C-x C-s) emacs will ask if a changelog entry should be added to the file before saving. If a comment is entered by the user, a new patch number is assigned to it and the comment is added to the file. This patch number will be the one that follows the most

recent changelog entry already in the file. This is obviously useful when maintaining version numbers individually for each file.

`<directory_name>`
: Global version control will be performed coherently on several files. When saving a buffer (C-x C-s) emacs will ask if a changelog entry should be added to the file before saving. If a comment is given, the global patch number (which will be kept in the file: `<directory_name>/GlobalPatch`) is atomically incremented and the changelog entry is added to the current file, associated to that patch number. Also, a small entry is added to a file `<directory_name>/GlobalChangeLog` which points to the current file. This allows inspecting all changes sequentially by visiting all the files where the changes were made (see C-c C-n). This is obviously useful when maintaining a single thread of version and patch numbers for a set of files.

`off`
: Turns off version control: C-x C-s then simply saves the file as usual.

Some useful tips:

- If a changelog entry is in fact introduced, the cursor is left at the point in the file where the comment was inserted and the mark is left at the original file point. This allows inspecting (and possibly modifying) the changelog entry, and then returning to the original point in the file by simply typing C-x C-x.
- The first changelog entry is entered by default at the end of the buffer. Later, the changelog entries can be moved anywhere else in the file. New changelog entries are always inserted just above the first changelog entry which appears in the file.
- The comments in changelog entries can be edited at any time.
- If a changelog entry is moved to another file, and version numbers are shared by several files through a directory, the corresponding file pointer in the `<directory_name>/GlobalChangeLog` file needs to be changed also, for the entry to be locatable later using C-c C-n.

⟨^C⟩ ⟨^S⟩ Same as C-x C-s except that it forces prompting for inclusion of a changelog entry even if the buffer is unmodified.

⟨^C⟩ ⟨n⟩ Force a move to a new major/minor version number (the user will be prompted for the new numbers). Only applicable if using directory-based version maintenance. Note that otherwise it suffices with introducing a changelog entry in the file and changing its version number by hand.

⟨^C⟩ ⟨^N⟩ When a unique version numbering is being maintained across several files, this command allows inspecting all changes sequentially by visiting all the files in which the changes were made:

- If in a source file, find the next changelog entry in the source file, open in another window the corresponding `GlobalChangeLog` file, and position the cursor at the corresponding entry. This allows browsing the previous and following changes made, which may perhaps reside in other files in the system.
- If in a `GlobalChangeLog` file, look for the next entry in the file, and open in another window the source file in which the corresponding comment resides, positioning the corresponding comment at the top of the screen. This allows going through a section of the `GlobalChangeLog` file checking all the corresponding comments in the different files in which they occur.

10.13 Generating program documentation

These commands provide some bindings and facilities for generating and viewing the documentation corresponding to the current buffer. The documentation is generated in a temporary directory, which is created automatically. This is quite useful while modifying the documentation for a file, in order to check the output that will be produced, whithout having to set up a documentation directory by hand or to regenerate a large manual of which the file may be a part.

⟨^C⟩ ⟨D⟩ ⟨B⟩ Generate the documentation for the current buffer in the default format. This allows generating a simple document for the current buffer. Basically, it creates a `SETTINGS` file, sets `MAIN` in `SETTINGS` to the current buffer and then generates the documentation in a temporary directory. Note that for generating complex manuals the best approach is to set up a permanent documentation directory with the appropriate `SETTINGS` and `Makefile` files (see the LPdoc manual).

⟨^C⟩ ⟨D⟩ ⟨F⟩ Change the default output format used by the LPdoc auto-documenter. It is set by default to `dvi` or to the environment variable `LPDOCFORMAT` if it is defined.

⟨^C⟩ ⟨D⟩ ⟨S⟩ Visit, or create, the `SETTINGS` file (which controls all auto-documenter options).

⟨^C⟩ ⟨D⟩ ⟨G⟩ Generate the documentation according to `SETTINGS` in the default format. This allows generating complex documents but it assumes that `SETTINGS` exists and that its options (main file, component files, paths, etc.) have been set properly. Documentation is generated in a temporary directory. Note however that for generating complex manuals the best approach is to set up a permanent documentation directory with the appropriate `SETTINGS` and `Makefile` files (see the LPdoc manual).

⟨^C⟩ ⟨D⟩ ⟨V⟩ Start a viewer on the documentation for the current buffer in the default format.

⟨^C⟩ ⟨D⟩ ⟨W⟩

Change the root working dir used by the LPdoc auto-documenter. It is set by default to a new dir under `/tmp` or to the environment variable `LPDOCWDIR` if it is defined.

10.14 Setting top level preprocessor and documenter executables

These commands allow *changing the executables used* when starting a Prolog top-level, the preprocessor, or the auto-documenter. They also allow changing the arguments that these executables take, and changing the path where the libraries reside. In the case of the top-level and preprocessor, this should be done only by users which understand the implications, but it is very useful if several versions of Ciao/Prolog or the preprocessor are available in the system. All these arguments can be changed through the *customize* options in the help menu (see Section 10.20 [Customization], page 75).

⟨^C⟩ ⟨S⟩ ⟨C⟩ Change the Ciao/Prolog executable used to run the Prolog-like top level. It is set by default to `ciao` or, to the environment variable `CIAO` if it is defined.

⟨^C⟩ ⟨S⟩ ⟨^C⟩

Change the arguments passed to the Ciao/Prolog executable. They are set by default to none or, to the environment variable `CIAOARGS` if it is defined.

⟨^C⟩ ⟨S⟩ ⟨P⟩ Change the executable used to run the Ciao Preprocessor toplevel. It is set by default to `ciaopp` or, to the environment variable `CIAOPP` if it is defined.

⟨^C⟩ ⟨S⟩ ⟨^P⟩

Change the arguments passed to the Ciao preprocessor executable. They are set by default to none or to the environment variable `CIAOPPARGS` if it is defined.

⟨^C⟩ ⟨S⟩ ⟨L⟩ Change the location of the Ciao/Prolog library paths (changes the environment variable `CIAOLIB`).

⟨^C⟩ ⟨S⟩ ⟨D⟩ Change the executable used to run the LPdoc auto-documenter. It is set by default to `lpdoc` or to the environment variable `LPDOC` if it is defined.

⟨^C⟩ ⟨S⟩ ⟨^D⟩
Change the arguments passed to the LPdoc auto-documenter. They are set by default to none or to the environment variable `LPDOCARGS` if it is defined.

⟨^C⟩ ⟨S⟩ ⟨^L⟩
Change the path in which the LPdoc library is installed. It is set by default to `/home/clip/lib` or to the environment variable `LPDOCLIB` if it is defined.

10.15 Other commands

Some other commands which are active in the Ciao/Prolog mode:

⟨^C⟩ ⟨^L⟩ Recenter the most recently used Ciao/Prolog inferior process buffer (top level or preprocessor).

10.16 Traditional Prolog Mode Commands

These commands provide some bindings and facilities for loading programs, which are present in emacs Prolog modes of other Prolog systems (e.g., SICStus). This is useful mainly if the Ciao/Prolog emacs mode is used with such Prolog systems. Note that the behavior of these commands in Ciao is slightly different from that of SICStus and their use (`compile/1` and `consult/1`) in the Ciao top-level are not recommended.

⟨^C⟩ ⟨K⟩ Compile the entire buffer.

⟨^C⟩ ⟨k⟩ Compile a given region.

⟨^C⟩ ⟨^K⟩ Compile the predicate around point.

⟨^C⟩ ⟨C⟩ Consult the entire buffer.

⟨^C⟩ ⟨c⟩ Consult a given region.

⟨^C⟩ ⟨^C⟩ Consult the predicate around point.

10.17 Coexistence with other Prolog interfaces

As mentioned previously, the Ciao/Prolog `emacs` interface can also be used to work with other Prolog or CLP systems. Also, the Ciao/Prolog `emacs` interface (*mode*) can coexist with other Prolog-related `emacs` interfaces (*modes*) (such as, e.g., the `SICStus` Prolog interface). Only one of the interfaces can be active at a time for a given buffer (i.e., for each given file opened inside `emacs`). In order the change a buffer to a given interface, move the cursor to that buffer and type `M-x ...-mode` (e.g., for the Ciao/Prolog mode, `M-x ciao-mode`).

If several Prolog-related `emacs` interfaces are loaded, then typically the *last* one to be loaded takes precedence, in the sense that this will be the interface in which `emacs` will be set when opening files which have a `.pl` ending (this depends a bit on how things are set up in your `.emacs` file).

10.18 Getting the Ciao/Prolog mode version

⟨^C⟩ ⟨v⟩ Report the version of the emacs Ciao/Prolog mode.

10.19 Using Ciao/Prolog mode capabilities in standard shells

The capabilities (commands, coloring, ...) which are active in the Ciao/Prolog *inferior* mode can also be made available in any standard command line shell which is being run within emacs. This can be enabled by going to the buffer in which the shell is running and typing "⟨M-x⟩ `ciao-inferior-mode`". This is very useful for example when running the stand-alone compiler, the `lpdoc` auto-documenter, or even certain user applications (those that use the standard error message library) in an emacs sub-shell. Turning the Ciao/Prolog inferior mode on on that sub-shell will highlight and color the error messages, and automatically find and visit the locations in the files in which the errors are reported.

Finally, one the most useful applications of this is when using the embedded debugger (a version of the debugger which can be embedded into executables so that an interactive debugging session can be triggered at any time while running that executable without needing the top-level shell). If an application is run in a shell buffer which has been set with Ciao inferior mode (⟨M-x⟩ `ciao-inferior-mode`) and this application starts emitting output from the embedded debugger (i.e., which contains the embedded debugger and is debugging its code) then the Ciao emacs mode will be able to follow these messages, for example tracking execution in the source level code. This also works if the application is written in a combination of languages, provided the parts written in Ciao are compiled with the embedded debugger package and is thus a covenient way of debugging multi-language applications. The only thing needed is to make sure that the output messages appear in a shell buffer that is in Ciao inferior mode.

10.20 Customization

This section explains all variables used in the Ciao/Prolog emacs mode which can be customized by users. Such customization can be performed (in later versions of `emacs`) from the `emacs` menus (`Help -> Customize -> Top-level Customization Group`), or also by adding a `setq` expression in the `.emacs` file. Such `setq` expression should be similar to:

```
(setq <variable> <new_value>)
```

The following sections list the different variables which can be customized for `ciao`, `ciaopp` and `lpdoc`.

10.20.1 Ciao variables

`ciao-clip-logo` (*file*)
: CLIP logo image.

`ciao-debug-breakpoint-color` (*face*)
: Color to use with breakpoints in source debugger.

`ciao-debug-call-color` (*face*)
: Color to use with the call port in source debugger.

`ciao-debug-exit-color` (*face*)
: Color to use with the exit port in source debugger.

`ciao-debug-expansion` (*face*)
: Color to use in source debugger when the predicate was not found.

`ciao-debug-fail-color` (*face*)
: Color to use with the fail port in source debugger.

`ciao-debug-redo-color` (*face*)
: Color to use with the redo port in source debugger.

`ciao-indent-width` (*integer*)
: Indentation for a new goal.

`ciao-logo` (*file*)
: Ciao logo image.

`ciao-main-filename` (*string*)
: Name of main file in a multiple module program. Setting thsi is very useful when working on a multi-module program because it allows issuing a load command after working on an inferior module which will reload from the main module, thus also reloading automatically all dependent modules.

`ciao-query` (*string*)
: Query to use in Ciao. Setting this is useful when using a long or complicated query because it saves from having to type it over and over again. It is possible to set that this query will be issued any time a program is (re)loaded.

`ciao-system` (*string*)
: Name of Ciao or Prolog executable which runs the classical Prolog-like top level.

`ciao-system-args` (*string*)
: *Arguments passed to Ciao/Prolog toplevel executable.

`ciao-toplevel-buffer-name` (*string*)
: Basic name of the buffer running the Ciao/Prolog toplevel inferior process.

10.20.2 CiaoPP variables

`ciao-ciaopp-buffer-name` (*string*)
: Basic name of the buffer running the Ciao preprocessor inferior process.

`ciao-ciaopp-system` (*string*)
: Name of Ciao preprocessor executable.

`ciao-ciaopp-system-args` (*string*)
: Arguments passed to Ciao preprocessor executable.

10.20.3 LPdoc variables

`ciao-lpdoc-buffer-name` (*string*)
: Basic name of the buffer running the auto-documenter inferior process.

`ciao-lpdoc-docformat` (*symbol*)
: Name of default output format used by LPdoc.

`ciao-lpdoc-libpath` (*directory*)
: Path in which the LPdoc library is installed.

`ciao-lpdoc-system` (*string*)
: Name of LPdoc auto-documenter executable.

`ciao-lpdoc-system-args` (*string*)
: Arguments passed to LPdoc executable.

`ciao-lpdoc-wdir-root` (*directory*)
: Name of root working dir used by LPdoc.

10.21 Installation of the Ciao/Prolog emacs interface

If opening a file ending with `.pl` puts emacs in another mode (such as `perl` mode, which is the –arguably incorrect– default setting in some `emacs` distributions), then either the emacs mode was not installed or the installation settings are being overwritten by other settings in your `.emacs` file or in some library. In any case, you can set things manually so that the Ciao/Prolog mode is loaded by default in your system. This can be done by including in your `.emacs` file a line such as:

```
(load <CIAOLIBDIR>/DOTemacs)
```

This loads the above mentioned file from the Ciao library, which contains the following lines (except that the paths are changed during installation to appropriate values for your system):

```
;; Ciao/Prolog mode initialization
;; ------------------------------
;; (can normally be used with other Prolog modes and the default prolog.el)
;;
(setq load-path (cons "<CIAOLIBDIR>" load-path))
(autoload 'run-ciao-toplevel "ciao"
          "Start a Ciao/Prolog top-level sub-process." t)
(autoload 'ciao "ciao"
          "Start a Ciao/Prolog top-level sub-process." t)
(autoload 'prolog "ciao"
          "Start a Ciao/Prolog top-level sub-process." t)
(autoload 'run-ciao-preprocessor "ciao"
          "Start a Ciao/Prolog preprocessor sub-process." t)
(autoload 'ciaopp "ciao"
          "Start a Ciao/Prolog preprocessor sub-process." t)
(autoload 'ciao-mode "ciao"
          "Major mode for editing and running Ciao/Prolog" t)
(autoload 'ciao-inferior-mode "ciao"
          "Major mode for running Ciao/Prolog, CiaoPP, LPdoc, etc." t)
(setq auto-mode-alist (cons '("\\.pl$" . ciao-mode) auto-mode-alist))
(setq auto-mode-alist (cons '("\\.pls$" . ciao-mode) auto-mode-alist))
(setq auto-mode-alist (cons '("\\.lpdoc$" . ciao-mode) auto-mode-alist))
(setq completion-ignored-extensions
      (append '(".dep" ".itf" ".po" ".asr" ".cpx")
              completion-ignored-extensions))
;; ------------------------------------------------------------------------
;; In Un*x, the following (or similar) lines should be included in your
;; .cshrc or .profile to find the manuals (the Ciao installation leaves
;; in the Ciao library directory 'DOTcshrc' and 'DOTprofile' files with
;; the right paths which can be included directly in your startup scripts):
;;
;; setenv INFOPATH /usr/local/info:/usr/info:<LPDOCDIR>
;; ------------------------------------------------------------------------
```

If you would like to configure things in a different way, you can also copy the contents of this file to your `.emacs` file and make the appropriate changes. For example, if you do not want `.pl` files to be put automatically in Ciao/Prolog mode, then comment out (or remove) the line:

```
(setq auto-mode-alist ... )
```

You will then need to switch manually to Ciao/Prolog mode by typing `M-x ciao-mode` after opening a Prolog file.

If you are able to open the Ciao/Prolog menu but the Ciao manuals are not found or the `ciao` command (the top-level) is not found when loading `.pl` files, the probable cause is that you do not have the Ciao paths in the `INFOPATH` and `MANPATH` *environment variables* (whether these variables are set automatically or not for users depends on how the Ciao system was installed). Under Un*x, you can add these paths easily by including the line:

```
source <CIAOLIBDIR>/DOTcshrc
```

in your `.login` or `.cshrc` files if you are using `csh` (or `tcsh`, etc.), or, alternatively, the line:

```
. <CIAOLIBDIR>/DOTprofile
```

in your `.login` or `.profile` files if you are using `sh` (or `bash`, etc.). See the Ciao installation instructions (Chapter 200 [Installing Ciao from the source distribution], page 735 or Chapter 201 [Installing Ciao from a Win32 binary distribution], page 745) for details.

10.22 Emacs version compatibility

This mode is currently being developed within `GNU emacs` version 20.5. It should also work with all other 20.XX and later 19.XX versions. We also try to keep things working under `xemacs`.

PART II - The Ciao basic language (engine)

Author(s): The Clip Group.

This part documents the *Ciao basic builtins*. These predefined predicates and declarations are available in every program, unless the `pure` package is used (by using a `:- module(_,_,[pure]).` declaration or `:- use_package(pure).`). These predicates are contained in the `engine` directory within the `lib` library. The rest of the library predicates, including the packages that provide most of the ISO-Prolog builtins, are documented in subsequent parts.

11 The module system

Author(s): Daniel Cabeza and the CLIP Group.

Version: 1.8#3 (2002/12/12, 20:24:36 CET)

Modularity is a basic notion in a modern computer language. Modules allow dividing programs in several parts, which have its own independent name spaces. The module system in Ciao [CH00a], as in many other Prolog implementations, is procedure based. This means that predicate names are local to a module, but functor/atom names in data are shared.

The predicates visible in a module are the predicates defined in that module, plus the predicates imported from other modules. Only predicates exported by a module can be imported from other modules. The default module of a given predicate name is the local one if the predicate is defined locally, else the last module from which the predicate is imported, having explicit imports priority (that is, a predicate imported by an `use_module/2` declaration is always preferred above a predicate imported by an `use_module/1` declaration). To refer to a predicate from a module which is not the default for that predicate the name has to be module qualified. A module qualified predicate name has the form `Module:Predicate` as in the call `debugger:debug_module(M)`. Note that this does not allow having access to predicates not imported, nor defining clauses of other modules.

All predicates defined in files with no module declaration belong to a special module called `user`, and all are implicitly exported. This allows dividing programs in several files without being aware of the module system at all. Note that this feature is only supported for compatibility reasons, being its use discouraged. Many attractive compilation features of Ciao cannot be performed in `user` modules.

The case of multifile predicates (defined with the declaration `multifile/1`) is also special. Multifile predicates can be defined by clauses distributed in several modules, and all modules which define a predicate as multifile can use that predicate. The name space of multifile predicates is independent, as if they belonged to special module `multifile`.

Every `user` or module file imports implicitly a number of modules called builtin modules. They are imported before all other importations of the module, allowing thus redefining any of their predicates (with the exception of `true/0`) by defining local versions or importing them from other modules. Importing explicitly from a builtin module, however, disables the implicit importation of the rest (this feature is used by package `library(pure)` to define pure prolog code).

11.1 Usage and interface (`modules`)

- **Library usage:**
  Modules are an intrinsic feature of Ciao, so nothing special has to be done to use them.

11.2 Documentation on internals (`modules`)

module/3: DECLARATION

Usage: `:- module(Name,Exports,Packages).`

- *Description:* Declares a module of name `Name` which exports the predicates in `Exports`, and uses the packages in `Packages`. `Name` must match with the name of the file where the module resides, without extension. For each source in `Packages`,

a package file is included, as if by an `include/1` declaration. If the source is specified with a path alias, this is the file included, if it is an atom, the library paths are searched. Package files provide functionalities by declaring imports from other modules, defining operators, new declarations, translations of code, etc.

This directive must appear the first in the file.

Also, if the compiler finds an unknown declaration as the first term in a file, the name of the declaration is regarded as a package library to be included, and the arguments of the declaration (if present) are interpreted like the arguments of `module/3`.

– *The following properties hold at call time:*

`Name` is a module name (an atom). (`modules:modulename/1`)

`Exports` is a list of `prednames`. (`basic_props:list/2`)

`Packages` is a list of `sourcenames`. (`basic_props:list/2`)

module/2: DECLARATION

Usage: `:- module(Name,Exports).`

– *Description:* Same as directive `module/3`, with an implicit package `iso`, which enables to include ISO-Prolog compatible code (compatibility not 100% yet).

– *The following properties hold at call time:*

`Name` is a module name (an atom). (`modules:modulename/1`)

`Exports` is a list of `prednames`. (`basic_props:list/2`)

export/1: DECLARATION

Usage 1: `:- export(Pred).`

– *Description:* Adds `Pred` to the set of exported predicates.

– *The following properties hold at call time:*

`Pred` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(`basic_props:predname/1`)

Usage 2: `:- export(Exports).`

– *Description:* Adds `Exports` to the set of exported predicates.

– *The following properties hold at call time:*

`Exports` is a list of `prednames`. (`basic_props:list/2`)

use_module/2: DECLARATION

Usage: `:- use_module(Module,Imports).`

– *Description:* Specifies that this code imports from the module defined in `Module` the predicates in `Imports`. The imported predicates must be exported by the other module.

– *The following properties hold at call time:*

`Module` is a source name. (`streams_basic:sourcename/1`)

`Imports` is a list of `prednames`. (`basic_props:list/2`)

use_module/1: DECLARATION

Usage: `:- use_module(Module).`

- *Description:* Specifies that this code imports from the module defined in `Module` all the predicates exported by it. The previous version with the explicit import list is preferred to this as it minimizes the chances to have to recompile this code if the other module changes.
- *The following properties hold at call time:*

  `Module` is a source name. (`streams_basic:sourcename/1`)

import/2: DECLARATION

Usage: `:- import(Module,Imports).`

- *Description:* Declares that this code imports from the module with name `Module` the predicates in `Imports`.

  Important note: this declaration is intended to be used when the current module or the imported module is going to be dynamically loaded, and so the compiler does not include the code of the imported module in the current executable (if only because the compiler cannot know the location of the module file at the time of compilation). For the same reason the predicates imported are not checked to be exported by `Module`. Its use in other cases is strongly discouraged, as it disallows many compiler optimizations.
- *The following properties hold at call time:*

  `Module` is a module name (an atom). (`modules:modulename/1`)

  `Imports` is a list of `prednames`. (`basic_props:list/2`)

reexport/2: DECLARATION

Usage: `:- reexport(Module,Preds).`

- *Description:* Specifies that this code reexports from the module defined in `Module` the predicates in `Preds`. This implies that this module imports from the module defined in `Module` the predicates in `Preds`, an also that this module exports the predicates in `Preds` .
- *The following properties hold at call time:*

  `Module` is a source name. (`streams_basic:sourcename/1`)

  `Preds` is a list of `prednames`. (`basic_props:list/2`)

reexport/1: DECLARATION

Usage: `:- reexport(Module).`

- *Description:* Specifies that this code reexports from the module defined in `Module` all the predicates exported by it. This implies that this module imports from the module defined in `Module` all the predicates exported by it, an also that this module exports all such predicates .
- *The following properties hold at call time:*

  `Module` is a source name. (`streams_basic:sourcename/1`)

meta_predicate/1: DECLARATION

Usage: `:- meta_predicate MetaSpecs.`

- *Description:* Specifies that the predicates in `MetaSpecs` have arguments which represent predicates and thus have to be module expanded. The directive is only mandatory for exported predicates (in modules). This directive is defined as a prefix operator in the compiler.
- *The following properties hold at call time:*

  `MetaSpecs` is a sequence of `metaspecs`. (`basic_props:sequence/2`)

modulename/1: REGTYPE

A module name is an atom, not containing characters ':' or '$'. Also, `user` and `multifile` are reserved, as well as the module names of all builtin modules (because in an executable all modules must have distinct names).

Usage: `modulename(M)`

- *Description:* `M` is a module name (an atom).

metaspec/1: REGTYPE

A meta-predicate specification for a predicate is the functor of that predicate applied to atoms which represent the kind of module expansion that should be done with the arguments. Possible contents are represented as:

`goal` This argument will be a term denoting a goal (either a simple or complex one) which will be called. For commpatibility reasons it can be named as `:` as well.

`clause` This argument will be a term denoting a clause.

`fact` This argument should be instantiated to a term denoting a fact (head-only clause).

`spec` This argument should be instantiated to a predicate name, as Functor/Arity.

`pred(`*N*`)` This argument should be instantiated to a predicate construct to be called by means of a `call/`*N* predicate call (see `call/2`).

`addmodule`
This is in fact is not a real meta-data specification. It specifies that in an argument added after this one will be passed the calling module, to allow handling more involved meta-data (e.g., lists of goals) by using conversion builtins.

`?,+,-,_` These other values denote that this argument is not module expanded.

Usage: `metaspec(M)`

- *Description:* `M` is a meta-predicate specification.

12 Directives for using code in other files

Author(s): Daniel Cabeza.

Version: 1.8#3 (2002/12/12, 20:24:36 CET)

Version of last change: 1.3#107 (1999/11/18, 13:6:14 MET)

Documentation for the directives used to load code into Ciao Prolog (both from the toplevel shell and by other modules).

12.1 Usage and interface (`loading_code`)

- **Library usage:**
  These directives are builtin in Ciao, so nothing special has to be done to use them.

12.2 Documentation on internals (`loading_code`)

ensure_loaded/1: DECLARATION

Usage: `:- ensure_loaded(File).` ⟨• ISO •⟩

- *Description:* Specifies that the code present in `File` will be included in the executable being prepared, in the `user` module. The file `File` cannot have a module declaration. This directive is intended to be used by programs not divided in modules. Dividing programs into modules is however strongly encouraged, since most of the attractive features of Ciao (such as static debugging and global optimization) are only partially available for `user` modules.
- *The following properties should hold at call time:*
  `File` is a source name. (`streams_basic:sourcename/1`)

include/1: DECLARATION

Usage: `:- include(File).` ⟨• ISO •⟩

- *Description:* The contents of the file `File` are included in the current program text exactly as if they had been written in place of this directive.
- *The following properties should hold at call time:*
  `File` is a source name. (`streams_basic:sourcename/1`)

use_package/1: DECLARATION

`:- use_package(Package).`

Specifies the use in this file of the packages defined in `Package`. See the description of the third argument of `module/3` for an explanation of package files.

This directive must appear the first in the file, or just after a `module/3` declaration. A file with no module declaration, in the absence of this directive, uses an implicit package `iso`, which enables to include ISO-Prolog compatible code (compatibility not 100% yet).

Usage 1: `:- use_package(Package).`

– *The following properties should hold at call time:*
`Package` is a source name. (`streams_basic:sourcename/1`)

Usage 2: :- `use_package(Package)`.
– *The following properties should hold at call time:*
`Package` is a list of `sourcenames`. (`basic_props:list/2`)

13 Control constructs/predicates

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#37 (2001/1/2, 16:47:3 CET)

This module contains the set of basic control predicates, except the predicates dealing with exceptions, which are in Chapter 23 [Exception handling], page 131.

13.1 Usage and interface (`basiccontrol`)

- **Library usage:**
  These predicates/constructs are builtin in Ciao, so nothing special has to be done to use them. In fact, as they are hardwired in some parts of the system, most of them cannot be redefined.
- **Exports:**
  - *Predicates:*
    `,/2`, `;/2`, `->/2`, `!/0`, `\+/1`, `if/3`, `true/0`, `fail/0`, `repeat/0`, `call/1`.

13.2 Documentation on exports (`basiccontrol`)

,/2: PREDICATE

`P , Q`

Conjunction (`P` *and* `Q`).

Usage 2: ISO

- *The following properties should hold at call time:*

  `P` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

  `Q` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

;/2: PREDICATE

`P ; Q`

Disjunction (`P` *or* `Q`).

Usage 2: ISO

- *The following properties should hold at call time:*

  `P` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

  `Q` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

->/2: PREDICATE

`P -> Q`

If `P` then `Q` else fail, using first solution of `P` only. Also, `(P -> Q ; R)`, if `P` then `Q` else `R`, using first solution of `P` only. No cuts are allowed in `P`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`P` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Q` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

!/0: PREDICATE

Usage 1: ⟨• ISO •⟩

– *Description:* Commit to any choices taken in the current predicate.

Usage 2: ⟨• ISO •⟩

– *Description:* Commit to any choices taken in the current predicate.

\+/1: PREDICATE

`\+ P`

Goal `P` is not provable (negation by failure). Fails if `P` has a solution, and succeeds otherwise. No cuts are allowed in `P`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`P` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

if/3: PREDICATE

`if(P,Q,R)`

If `P` then `Q` else `R`, exploring all solutions of `P`. No cuts are allowed in `P`.

Usage 2:

– *The following properties should hold at call time:*

`P` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Q` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`R` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

true/0: PREDICATE

Usage 1: ⟨• ISO •⟩

– *Description:* Succeed (noop).

Usage 2: ⟨• ISO •⟩

– *Description:* Succeed (noop).

fail/0: PREDICATE

Usage 1: ⟨• ISO •⟩

– *Description:* Fail, backtrack immediately.

Usage 2: ⟨• ISO •⟩

– *Description:* Fail, backtrack immediately.

repeat/0: PREDICATE

Usage 1: ⟨• ISO •⟩

– *Description:* Generates an infinite sequence of backtracking choices.

Usage 2: ⟨• ISO •⟩

– *Description:* Generates an infinite sequence of backtracking choices.

call/1: PREDICATE

`call(G)`

Executes goal `G`, restricting the scope of the cuts to the execution of `G`. Equivalent to writing a variable `G` in a goal position.

Meta-predicate with arguments: `call(goal)`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`G` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

13.3 Documentation on internals (`basiccontrol`)

|/2: PREDICATE

An alias for disjunction (when appearing outside a list). The alias is performed when terms are read in.

14 Basic builtin directives

Author(s): Daniel Cabeza.

Version: 1.8#3 (2002/12/12, 20:24:36 CET)

Version of last change: 1.7#165 (2002/1/3, 17:38:59 CET)

This chapter documents the basic builtin directives in Ciao, additional to the documented in other chapters. These directives are natively interpreted by the Ciao compiler (`ciaoc`).

Unlike in other Prolog systems, directives in Ciao are not goals to be *executed* by the compiler or top level. Instead, they are *read* and acted upon by these programs. The advantage of this is that the effect of the directives is consistent for executables, code loaded in the top level, code analyzed by the preprocessor, etc.

As a result, by default only the builtin directives or declarations defined in this manual can be used in user programs. However, it is possible to define new declarations using the `new_declaration/1` and `new_declaration/2` directives (or using packages including them). Also, packages may define new directives via code translations.

14.1 Usage and interface (`builtin_directives`)

- **Library usage:**
  These directives are builtin in Ciao, so nothing special has to be done to use them.

14.2 Documentation on internals (`builtin_directives`)

multifile/1: DECLARATION

Usage: `:- multifile Predicates.` ⟨• ISO •⟩

- *Description:* Specifies that each predicate in `Predicates` may have clauses in more than one file. Each file that contains clauses for a multifile predicate must contain a directive multifile for the predicate. The directive should precede all clauses of the affected predicates. This directive is defined as a prefix operator in the compiler.
- *The following properties should hold at call time:*
  `Predicates` is a sequence or list of `prednames`. (`basic_props:sequence_or_list/2`)

discontiguous/1: DECLARATION

Usage: `:- discontiguous Predicates.` ⟨• ISO •⟩

- *Description:* Specifies that each predicate in `Predicates` may be defined in this file by clauses which are not in consecutive order. Otherwise, a warning is signaled by the compiler when clauses of a predicate are not consecutive (this behavior is controllable by the prolog flag *discontiguous_warnings*). The directive should precede all clauses of the affected predicates. This directive is defined as a prefix operator in the compiler.
- *The following properties should hold at call time:*
  `Predicates` is a sequence or list of `prednames`. (`basic_props:sequence_or_list/2`)

impl_defined/1: DECLARATION

Usage: :- `impl_defined(Predicates)`.

- *Description:* Specifies that each predicate in `Predicates` is *impl*icitly *defined* in the current prolog source, either because it is a builtin predicate or because it is defined in a C file. Otherwise, a warning is signaled by the compiler when an exported predicate is not defined in the module or imported from other module.
- *The following properties should hold at call time:*

  `Predicates` is a sequence or list of `prednames`. (`basic_props:sequence_or_list/2`)

redefining/1: DECLARATION

Usage: :- `redefining(Predicate)`.

- *Description:* Specifies that this module redefines predicate `Predicate`, also imported from other module, or imports it from more than one module. This prevents the compiler giving warnings about redefinitions of that predicate. `Predicate` can be partially (or totally) uninstantiated, to allow disabling those warnings for several (or all) predicates at once.
- *The following properties should hold at call time:*

  `Predicate` is *compatible* with `predname` (`basic_props:compat/2`)

initialization/1: DECLARATION

Usage: :- `initialization(Goal)`. ⟨• ISO •⟩

- *Description:* `Goal` will be executed at the start of the execution of any program containing the current code. The initialization of a module/file never runs before the initializations of the modules from which the module/file imports (excluding circular dependences).
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

on_abort/1: DECLARATION

Usage: :- `on_abort(Goal)`.

- *Description:* `Goal` will be executed after an abort of the execution of any program containing the current code.
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

15 Basic data types and properties

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#204 (2002/4/22, 18:42:18 CEST)

This library contains the set of basic properties used by the builtin predicates, and which constitute the basic data types and properties of the language. They can be used both as type testing builtins within programs (by calling them explicitly) and as properties in assertions.

15.1 Usage and interface (basic_props)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Properties:*
    `member/2`, `compat/2`, `iso/1`, `not_further_inst/2`, `regtype/1`.
  - *Regular Types:*
    `term/1`, `int/1`, `nnegint/1`, `flt/1`, `num/1`, `atm/1`, `struct/1`, `gnd/1`, `constant/1`, `callable/1`, `operator_specifier/1`, `list/1`, `list/2`, `sequence/2`, `sequence_or_list/2`, `character_code/1`, `string/1`, `predname/1`, `atm_or_atm_list/1`.

15.2 Documentation on exports (basic_props)

term/1: REGTYPE

The most general type (includes all possible terms).

Usage 1: `term(X)`

- *Description:* `X` is any term.

Usage 2: `term(X)`

- *Description:* `X` is any term.

int/1: REGTYPE

The type of integers. The range of integers is `[-2^2147483616, 2^2147483616)`. Thus for all practical purposes, the range of integers can be considered infinite.

Usage 1: `int(T)`

- *Description:* `T` is an integer.

Usage 2: `int(T)`

- *Description:* `T` is an integer.

nnegint/1: REGTYPE

The type of non-negative integers, i.e., natural numbers.

Usage 1: `nnegint(T)`

– *Description:* `T` is a non-negative integer.

Usage 2: `nnegint(T)`

– *Description:* `T` is a non-negative integer.

flt/1: REGTYPE

The type of floating-point numbers. The range of floats is the one provided by the C `double` type, typically `[4.9e-324, 1.8e+308]` (plus or minus). There are also three special values: Infinity, either positive or negative, represented as `1.0e1000` and `-1.0e1000`; and Not-a-number, which arises as the result of indeterminate operations, represented as `0.Nan`

Usage 1: `flt(T)`

– *Description:* `T` is a float.

Usage 2: `flt(T)`

– *Description:* `T` is a float.

num/1: REGTYPE

The type of numbers, that is, integer or floating-point.

Usage 1: `num(T)`

– *Description:* `T` is a number.

Usage 2: `num(T)`

– *Description:* `T` is a number.

atm/1: REGTYPE

The type of atoms, or non-numeric constants. The size of atoms is unbound.

Usage 1: `atm(T)`

– *Description:* `T` is an atom.

Usage 2: `atm(T)`

– *Description:* `T` is an atom.

struct/1: REGTYPE

The type of compound terms, or terms with non-zeroary functors. By now there is a limit of 255 arguments.

Usage 1: `struct(T)`

– *Description:* `T` is a compound term.

Usage 2: `struct(T)`

– *Description:* `T` is a compound term.

gnd/1: REGTYPE

The type of all terms without variables.

Usage 1: `gnd(T)`

– *Description:* `T` is ground.

Usage 2: `gnd(T)`

– *Description:* `T` is ground.

constant/1: REGTYPE

Usage 1: `constant(T)`

– *Description:* `T` is an atomic term (an atom or a number).

Usage 2: `constant(T)`

– *Description:* `T` is an atomic term (an atom or a number).

callable/1: REGTYPE

Usage 1: `callable(T)`

– *Description:* `T` is a term which represents a goal, i.e., an atom or a structure.

Usage 2: `callable(T)`

– *Description:* `T` is a term which represents a goal, i.e., an atom or a structure.

operator_specifier/1: REGTYPE

The type and associativity of an operator is described by the following mnemonic atoms:

`xfx`	Infix, non-associative: it is a requirement that both of the two subexpressions which are the arguments of the operator must be of *lower* precedence than the operator itself.
`xfy`	Infix, right-associative: only the first (left-hand) subexpression must be of lower precedence; the right-hand subexpression can be of the *same* precedence as the main operator.
`yfx`	Infix, left-associative: same as above, but the other way around.
`fx`	Prefix, non-associative: the subexpression must be of *lower* precedence than the operator.
`fy`	Prefix, associative: the subexpression can be of the *same* precedence as the operator.
`xf`	Postfix, non-associative: the subexpression must be of *lower* precedence than the operator.
`yf`	Postfix, associative: the subexpression can be of the *same* precedence as the operator.

Usage 1: `operator_specifier(X)`

– *Description:* `X` specifies the type and associativity of an operator.

Usage 2: `operator_specifier(X)`

– *Description:* `X` specifies the type and associativity of an operator.

list/1: REGTYPE

A list is formed with successive applications of the functor `'.'/2`, and its end is the atom `[]`. Defined as

```
list([]).
list([_1|L]) :-
        list(L).
list([]).
list([_1|L]) :-
        list(L).
```

Usage 1: `list(L)`

– *Description:* `L` is a list.

Usage 2: `list(L)`

– *Description:* `L` is a list.

list/2: REGTYPE

`list(L,T)`

`L` is a list, and for all its elements, `T` holds.

Meta-predicate with arguments: `list(?,pred(1))`.

Usage 1: `list(L,T)`

– *Description:* `L` is a list of `T`s.

Usage 2: `list(L,T)`

– *Description:* `L` is a list of `T`s.

member/2: PROPERTY

Usage 1: `member(X,L)`

– *Description:* `X` is an element of `L`.

Usage 2: `member(X,L)`

– *Description:* `X` is an element of `L`.

sequence/2: REGTYPE

A sequence is formed with zero, one or more occurrences of the operator `','/2`. For example, `a, b, c` is a sequence of three atoms, `a` is a sequence of one atom.

Meta-predicate with arguments: `sequence(?,pred(1))`.

Usage 1: `sequence(S,T)`

– *Description:* `S` is a sequence of `T`s.

Usage 2: `sequence(S,T)`

– *Description:* `S` is a sequence of `T`s.

sequence_or_list/2: REGTYPE

Meta-predicate with arguments: `sequence_or_list(?,pred(1))`.

Usage 1: `sequence_or_list(S,T)`

– *Description:* `S` is a sequence or list of `T`s.

Usage 2: `sequence_or_list(S,T)`

– *Description:* `S` is a sequence or list of `T`s.

character_code/1: REGTYPE

Usage 1: `character_code(T)`

– *Description:* `T` is an integer which is a character code.

– *The following properties hold upon exit:*

`T` is an integer. (`basic_props:int/1`)

Usage 2: `character_code(T)`

– *Description:* `T` is an integer which is a character code.

– *The following properties hold upon exit:*

`T` is an integer. (`basic_props:int/1`)

string/1: REGTYPE

A string is a list of character codes. The usual syntax for strings `"string"` is allowed, which is equivalent to `[0's,0't,0'r,0'i,0'n,0'g]` or `[115,116,114,105,110,103]`. There is also a special Ciao syntax when the list is not complete: `"st"||R` is equivalent to `[0's,0't|R]`.

Usage 1: `string(T)`

– *Description:* `T` is a string (a list of character codes).

– *The following properties hold upon exit:*

`T` is a list of `character_code`s. (`basic_props:list/2`)

Usage 2: `string(T)`

– *Description:* `T` is a string (a list of character codes).

– *The following properties hold upon exit:*

`T` is a list of `character_code`s. (`basic_props:list/2`)

predname/1: REGTYPE

Usage 1: `predname(P)`

– *Description:* `P` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
predname(P/A) :-
        atm(P),
        nnegint(A).
```

Usage 2: `predname(P)`

– *Description:* `P` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
predname(P/A) :-
        atm(P),
        nnegint(A).
```

atm_or_atm_list/1: REGTYPE

Usage 1: `atm_or_atm_list(T)`

– *Description:* `T` is an atom or a list of atoms.

Usage 2: `atm_or_atm_list(T)`

– *Description:* `T` is an atom or a list of atoms.

compat/2: PROPERTY

This property captures the notion of type or property compatibility. The instantiation or constraint state of the term is compatible with the given property, in the sense that assuming that imposing that property on the term does not render the store inconsistent. For example, terms `X` (i.e., a free variable), `[Y|Z]`, and `[Y,Z]` are all compatible with the regular type `list/1`, whereas the terms `f(a)` and `[1|2]` are not.

Meta-predicate with arguments: `compat(?,pred(1))`.

Usage 1: `compat(Term,Prop)`

– *Description:* `Term` is *compatible* with `Prop`

Usage 2: `compat(Term,Prop)`

– *Description:* `Term` is *compatible* with `Prop`

iso/1: PROPERTY

Usage 1: `iso(G)`

– *Description: Complies with the ISO-Prolog standard.*

Usage 2: `iso(G)`

– *Description: Complies with the ISO-Prolog standard.*

not_further_inst/2: PROPERTY

Usage 1: `not_further_inst(G,V)`

– *Description:* `V` is not further instantiated.

Usage 2: `not_further_inst(G,V)`

– *Description:* `V` is not further instantiated.

regtype/1: PROPERTY

Usage 1: `regtype(G)`

– *Description:* Defines a regular type.

Usage 2: `regtype(G)`

– *Description:* Defines a regular type.

16 Extra-logical properties for typing

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 0.7#8 (1998/9/23, 19:21:44 MEST)

This library contains traditional Prolog predicates for testing types. They depend on the state of instantiation of their arguments, thus being of extra-logical nature.

16.1 Usage and interface (term_typing)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Properties:*
    `var/1`, `nonvar/1`, `atom/1`, `integer/1`, `float/1`, `number/1`, `atomic/1`, `ground/1`, `type/2`.

16.2 Documentation on exports (term_typing)

var/1: PROPERTY

Usage 1: `var(X)`

- *Description:* `X` is a free variable.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `var(X)`

- *Description:* `X` is a free variable.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

nonvar/1: PROPERTY

Usage 1: `nonvar(X)`

- *Description:* `X` is currently a term which is not a free variable.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `nonvar(X)`

- *Description:* `X` is currently a term which is not a free variable.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

atom/1: PROPERTY

Usage 1: `atom(X)`

- *Description:* `X` is currently instantiated to an atom.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `atom(X)`

- *Description:* `X` is currently instantiated to an atom.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

integer/1: PROPERTY

Usage 1: `integer(X)`

- *Description:* `X` is currently instantiated to an integer.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `integer(X)`

- *Description:* `X` is currently instantiated to an integer.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

float/1: PROPERTY

Usage 1: `float(X)`

- *Description:* `X` is currently instantiated to a float.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `float(X)`

- *Description:* `X` is currently instantiated to a float.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

number/1: PROPERTY

Usage 1: `number(X)`

- *Description:* `X` is currently instantiated to a number.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `number(X)`

- *Description:* `X` is currently instantiated to a number.
- *The following properties hold globally:*
  `X` is not further instantiated. (`basic_props:not_further_inst/2`)

atomic/1: PROPERTY

Usage 1: `atomic(X)`

– *Description:* `X` is currently instantiated to an atom or a number.

– *The following properties hold globally:*

`X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `atomic(X)`

– *Description:* `X` is currently instantiated to an atom or a number.

– *The following properties hold globally:*

`X` is not further instantiated. (`basic_props:not_further_inst/2`)

ground/1: PROPERTY

Usage 1: `ground(X)`

– *Description:* `X` is currently ground (it contains no variables).

– *The following properties hold globally:*

`X` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `ground(X)`

– *Description:* `X` is currently ground (it contains no variables).

– *The following properties hold globally:*

`X` is not further instantiated. (`basic_props:not_further_inst/2`)

type/2: PROPERTY

Usage 1: `type(X,Y)`

– *Description:* `X` is internally of type `Y` (`var`, `attv`, `float`, `integer`, `structure`, `atom` or `list`).

– *The following properties hold upon exit:*

`Y` is an atom. (`basic_props:atm/1`)

Usage 2: `type(X,Y)`

– *Description:* `X` is internally of type `Y` (`var`, `attv`, `float`, `integer`, `structure`, `atom` or `list`).

– *The following properties hold upon exit:*

`Y` is an atom. (`basic_props:atm/1`)

17 Basic term manipulation

Author(s): Daniel Cabeza, Manuel Hermenegildo.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

17.1 Usage and interface (term_basic)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `arg/3`, `functor/3`, `=../2`, `copy_term/2`, `C/3`.
  - *Properties:*
    `=/2`.

17.2 Documentation on exports (term_basic)

=/2: PROPERTY

Usage 1: `X = Y` ⟨• ISO •⟩

- *Description:* `X` and `Y` unify.

Usage 2: `X = Y` ⟨• ISO •⟩

- *Description:* `X` and `Y` unify.

arg/3: PREDICATE

Usage 1: `arg(+ArgNo,+Term,?Arg)` ⟨• ISO •⟩

- *Description:* Argument `ArgNo` of the term `Term` is `Arg`.
- *The following properties should hold at call time:*
  `ArgNo` is currently instantiated to an integer. (`term_typing:integer/1`)

Usage 2: `arg(ArgNo,Term,Arg)` ⟨• ISO •⟩

- *Description:* Argument `ArgNo` of the term `Term` is `Arg`.
- *The following properties should hold at call time:*
  `ArgNo` is currently a term which is not a free variable. (`term_typing:nonvar/1`)
  `Term` is currently a term which is not a free variable. (`term_typing:nonvar/1`)
  `ArgNo` is currently instantiated to an integer. (`term_typing:integer/1`)

functor/3: PREDICATE

Usage 1: `functor(?Term,?Name,?Arity)` ⟨• ISO •⟩

- *Description:* The principal functor of the term `Term` has name `Name` and arity `Arity`.

Usage 2: `functor(Term,Name,Arity)` ⟨• ISO •⟩

- *Description:* The principal functor of the term `Term` has name `Name` and arity `Arity`.

=../2: PREDICATE

Usage 1: `?Term =.. ?List` ⟨• ISO •⟩

– *Description:* The functor and arguments of the term `Term` comprise the list `List`.

Usage 2: `Term =.. List` ⟨• ISO •⟩

– *Description:* The functor and arguments of the term `Term` comprise the list `List`.

copy_term/2: PREDICATE

Usage 1: `copy_term(Term,Copy)` ⟨• ISO •⟩

– *Description:* `Copy` is a renaming of `Term`, such that brand new variables have been substituted for all variables in `Term`. If any of the variables of `Term` have attributes, the copied variables will have copies of the attributes as well. It behaves as if defined by:

```
:- data 'copy of'/1.

copy_term(X, Y) :-
        asserta_fact('copy of'(X)),
        retract_fact('copy of'(Y)).
```

Usage 2: `copy_term(Term,Copy)` ⟨• ISO •⟩

– *Description:* `Copy` is a renaming of `Term`, such that brand new variables have been substituted for all variables in `Term`. If any of the variables of `Term` have attributes, the copied variables will have copies of the attributes as well. It behaves as if defined by:

```
:- data 'copy of'/1.

copy_term(X, Y) :-
        asserta_fact('copy of'(X)),
        retract_fact('copy of'(Y)).
```

C/3: PREDICATE

Usage 1: `C(?S1,?Terminal,?S2)`

– *Description:* `S1` is connected by the terminal `Terminal` to `S2`. Internally used in *DCG grammar rules*. Defined as if by the single clause: `'C'([X|S], X, S).`

Usage 2: `C(S1,Terminal,S2)`

– *Description:* `S1` is connected by the terminal `Terminal` to `S2`. Internally used in *DCG grammar rules*. Defined as if by the single clause: `'C'([X|S], X, S).`

18 Comparing terms

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

These built-in predicates are extra-logical. They treat uninstantiated variables as objects with values which may be compared, and they never instantiate those variables. They should *not* be used when what you really want is arithmetic comparison or unification.

The predicates make reference to a *standard total ordering* of terms, which is as follows:

- Variables, by age (roughly, oldest first – the order is *not* related to the names of variables).
- Floats, in numeric order (e.g. -1.0 is put before 1.0).
- Integers, in numeric order (e.g. -1 is put before 1).
- Atoms, in alphabetical (i.e. character code) order.
- Compound terms, ordered first by arity, then by the name of the principal functor, then by the arguments in left-to-right order. Recall that lists are equivalent to compound terms with principal functor `'.'/2`.

For example, here is a list of terms in standard order:

```
[ X, -1.0, -9, 1, bar, foo, [1], X = Y, foo(0,2), bar(1,1,1) ]
```

18.1 Usage and interface (term_compare)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `compare/3`.
  - *Properties:*
    `==/2`, `\==/2`, `@</2`, `@=</2`, `@>/2`, `@>=/2`.

18.2 Documentation on exports (term_compare)

==/2: PROPERTY

Usage 1: `Term1 == Term2`

- *Description:* The terms `Term1` and `Term2` are strictly identical.
- *The following properties should hold globally:*
  `Term1` is not further instantiated. (`basic_props:not_further_inst/2`)
  `Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `Term1 == Term2`

- *Description:* The terms `Term1` and `Term2` are strictly identical.
- *The following properties should hold globally:*
  `Term1` is not further instantiated. (`basic_props:not_further_inst/2`)
  `Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

\==/2: PROPERTY

Usage 1: `Term1 \== Term2`

– *Description:* The terms `Term1` and `Term2` are not strictly identical.

– *The following properties should hold globally:*

`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)

`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `Term1 \== Term2`

– *Description:* The terms `Term1` and `Term2` are not strictly identical.

– *The following properties should hold globally:*

`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)

`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

@</2: PROPERTY

Usage 1: `@<(Term1,Term2)`

– *Description:* The term `Term1` precedes the term `Term2` in the standard order.

– *The following properties should hold globally:*

`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)

`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `@<(Term1,Term2)`

– *Description:* The term `Term1` precedes the term `Term2` in the standard order.

– *The following properties should hold globally:*

`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)

`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

@=</2: PROPERTY

Usage 1: `@=<(Term1,Term2)`

– *Description:* The term `Term1` precedes or is identical to the term `Term2` in the standard order.

– *The following properties should hold globally:*

`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)

`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `@=<(Term1,Term2)`

– *Description:* The term `Term1` precedes or is identical to the term `Term2` in the standard order.

– *The following properties should hold globally:*

`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)

`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

@>/2: PROPERTY

Usage 1: `@>(Term1,Term2)`

– *Description:* The term `Term1` follows the term `Term2` in the standard order.

– *The following properties should hold globally:*
`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)
`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `@>(Term1,Term2)`
– *Description:* The term `Term1` follows the term `Term2` in the standard order.
– *The following properties should hold globally:*
`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)
`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

@>=/2: PROPERTY

Usage 1: `@>=(Term1,Term2)`
– *Description:* The term `Term1` follows or is identical to the term `Term2` in the standard order.
– *The following properties should hold globally:*
`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)
`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

Usage 2: `@>=(Term1,Term2)`
– *Description:* The term `Term1` follows or is identical to the term `Term2` in the standard order.
– *The following properties should hold globally:*
`Term1` is not further instantiated. (`basic_props:not_further_inst/2`)
`Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

compare/3: PREDICATE

`compare(Op,Term1,Term2)`

`Op` is the result of comparing the terms `Term1` and `Term2`.

Usage 1: `compare(?atm,@term,@term)`
– *The following properties should hold upon exit:*
`?atm` is an element of `[=,>,<]`. (`basic_props:member/2`)
`@term` is any term. (`basic_props:term/1`)
`@term` is any term. (`basic_props:term/1`)

Usage 2:
– *Call and exit should be compatible with:*
`Op` is an atom. (`basic_props:atm/1`)
– *The following properties should hold at call time:*
`Term1` is any term. (`basic_props:term/1`)
`Term2` is any term. (`basic_props:term/1`)
– *The following properties should hold upon exit:*
`Op` is an atom. (`basic_props:atm/1`)
`Term1` is any term. (`basic_props:term/1`)
`Term2` is any term. (`basic_props:term/1`)
`Op` is an element of `[=,>,<]`. (`basic_props:member/2`)
`Term1` is any term. (`basic_props:term/1`)
`Term2` is any term. (`basic_props:term/1`)

– *The following properties should hold globally:*
  `Term1` is not further instantiated. (`basic_props:not_further_inst/2`)
  `Term2` is not further instantiated. (`basic_props:not_further_inst/2`)

19 Basic predicates handling names of constants

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

The Ciao system provides builtin predicates which allow dealing with names of constants (atoms or numbers). As an atom name must be of less than 512 characters, to handle sequences of more characters, strings (character code lists) must be used.

19.1 Usage and interface (atomic_basic)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `name/2`, `atom_codes/2`, `number_codes/2`, `number_codes/3`, `atom_length/2`, `atom_concat/3`, `sub_atom/4`.

19.2 Documentation on exports (atomic_basic)

name/2: PREDICATE

`name(Const,String)`

`String` is the list of the ASCII codes of the characters comprising the name of `Const`. Note that if `Const` is an atom whose name can be interpreted as a number (e.g. '96'), the predicate is not reversible, as that atom will not be constructed when `Const` is uninstantiated. Thus it is recommended that new programs use the ISO-compliant predicates `atom_codes/2` or `number_codes/2`, as these predicates do not have this inconsistency.

Usage 2: `name(-constant,+string)`

- *Description:* If `String` can be interpreted as a number, `Const` is unified with that number, otherwise with the atom whose name is `String`.

Usage 3:

- *Calls should, and exit will be compatible with:*
  `String` is a string (a list of character codes). (`basic_props:string/1`)
- *The following properties should hold at call time:*
  `Const` is an atomic term (an atom or a number). (`basic_props:constant/1`)
- *The following properties hold upon exit:*
  `String` is a string (a list of character codes). (`basic_props:string/1`)

Usage 4:

- *Description:* If `String` can be interpreted as a number, `Const` is unified with that number, otherwise with the atom whose name is `String`.
- *The following properties should hold at call time:*
  `Const` is a free variable. (`term_typing:var/1`)
  `String` is a string (a list of character codes). (`basic_props:string/1`)
- *The following properties hold upon exit:*
  `Const` is an atomic term (an atom or a number). (`basic_props:constant/1`)

atom_codes/2: PREDICATE

`atom_codes(Atom,String)`

`String` is the list of the ASCII codes of the characters comprising the name of `Atom`.

Usage 3: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`String` is a string (a list of character codes). (`basic_props:string/1`)

– *The following properties should hold at call time:*

`Atom` is an atom. (`basic_props:atm/1`)

– *The following properties hold upon exit:*

`String` is a string (a list of character codes). (`basic_props:string/1`)

Usage 4: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Atom` is a free variable. (`term_typing:var/1`)

`String` is a string (a list of character codes). (`basic_props:string/1`)

– *The following properties hold upon exit:*

`Atom` is an atom. (`basic_props:atm/1`)

number_codes/2: PREDICATE

`number_codes(Number,String)`

`String` is the list of the ASCII codes of the characters comprising a representation of `Number`.

Usage 3: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`String` is a string (a list of character codes). (`basic_props:string/1`)

– *The following properties should hold at call time:*

`Number` is a number. (`basic_props:num/1`)

– *The following properties hold upon exit:*

`String` is a string (a list of character codes). (`basic_props:string/1`)

Usage 4: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Number` is a free variable. (`term_typing:var/1`)

`String` is a string (a list of character codes). (`basic_props:string/1`)

– *The following properties hold upon exit:*

`Number` is a number. (`basic_props:num/1`)

number_codes/3: PREDICATE

`number_codes(Number,String,Base)`

`String` is the list of the ASCII codes of the characters comprising a representation of `Number` in base `Base`.

Usage 3:

– *Calls should, and exit will be compatible with:*

`String` is a string (a list of character codes). (`basic_props:string/1`)

– *The following properties should hold at call time:*
`Number` is a number. (`basic_props:num/1`)
`Base` is an integer. (`basic_props:int/1`)
– *The following properties hold upon exit:*
`String` is a string (a list of character codes). (`basic_props:string/1`)

Usage 4:
– *The following properties should hold at call time:*
`Number` is a free variable. (`term_typing:var/1`)
`String` is a string (a list of character codes). (`basic_props:string/1`)
`Base` is an integer. (`basic_props:int/1`)
– *The following properties hold upon exit:*
`Number` is a number. (`basic_props:num/1`)

atom_length/2: PREDICATE

`atom_length(Atom,Length)`

`Length` is the number of characters forming the name of `Atom`.

Usage 2: ⟨• ISO •⟩
– *Calls should, and exit will be compatible with:*
`Length` is an integer. (`basic_props:int/1`)
– *The following properties should hold at call time:*
`Atom` is an atom. (`basic_props:atm/1`)
– *The following properties hold upon exit:*
`Length` is an integer. (`basic_props:int/1`)

atom_concat/3: PREDICATE

`atom_concat(Atom_1,Atom_2,Atom_12)`

`Atom_12` is the result of concatenating `Atom_1` followed by `Atom_2`.

Usage 1: `atom_concat(+atom,+atom,?atom)` ⟨• ISO •⟩
– *Description:* Concatenate two atoms.

Usage 2: `atom_concat(-atom,-atom,+atom)` ⟨• ISO •⟩
– *Description:* Non-deterministically split an atom.

Usage 3: `atom_concat(-atom,+atom,+atom)` ⟨• ISO •⟩
– *Description:* Take out of an atom a certain suffix (or fail if it cannot be done).

Usage 4: `atom_concat(+atom,-atom,+atom)` ⟨• ISO •⟩
– *Description:* Take out of an atom a certain prefix (or fail if it cannot be done).

Usage 5: ⟨• ISO •⟩
– *Description:* Concatenate two atoms.
– *Calls should, and exit will be compatible with:*
`Atom_12` is currently instantiated to an atom. (`term_typing:atom/1`)
– *The following properties should hold at call time:*
`Atom_1` is currently instantiated to an atom. (`term_typing:atom/1`)
`Atom_2` is currently instantiated to an atom. (`term_typing:atom/1`)

– *The following properties hold upon exit:*
`Atom_12` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 6: ⟨• ISO •⟩

– *Description:* Non-deterministically split an atom.
– *The following properties should hold at call time:*
`Atom_1` is a free variable. (`term_typing:var/1`)
`Atom_2` is a free variable. (`term_typing:var/1`)
`Atom_12` is currently instantiated to an atom. (`term_typing:atom/1`)
– *The following properties hold upon exit:*
`Atom_1` is currently instantiated to an atom. (`term_typing:atom/1`)
`Atom_2` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 7: ⟨• ISO •⟩

– *Description:* Take out of an atom a certain suffix (or fail if it cannot be done).
– *The following properties should hold at call time:*
`Atom_1` is a free variable. (`term_typing:var/1`)
`Atom_2` is currently instantiated to an atom. (`term_typing:atom/1`)
`Atom_12` is currently instantiated to an atom. (`term_typing:atom/1`)
– *The following properties hold upon exit:*
`Atom_1` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 8: ⟨• ISO •⟩

– *Description:* Take out of an atom a certain prefix (or fail if it cannot be done).
– *The following properties should hold at call time:*
`Atom_1` is currently instantiated to an atom. (`term_typing:atom/1`)
`Atom_2` is a free variable. (`term_typing:var/1`)
`Atom_12` is currently instantiated to an atom. (`term_typing:atom/1`)
– *The following properties hold upon exit:*
`Atom_2` is currently instantiated to an atom. (`term_typing:atom/1`)

sub_atom/4: PREDICATE

`sub_atom(Atom,Before,Length,Sub_atom)`

`Sub_atom` is formed with `Length` consecutive characters of `Atom` after the `Before` character. For example, the goal `sub_atom(summer,1,4,umme)` succeeds.

Usage 2:

– *Calls should, and exit will be compatible with:*
`Sub_atom` is an atom. (`basic_props:atm/1`)
– *The following properties should hold at call time:*
`Atom` is an atom. (`basic_props:atm/1`)
`Before` is currently instantiated to an integer. (`term_typing:integer/1`)
`Length` is currently instantiated to an integer. (`term_typing:integer/1`)
– *The following properties hold upon exit:*
`Sub_atom` is an atom. (`basic_props:atm/1`)

20 Arithmetic

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 0.9#18 (1999/3/23, 21:6:13 MET)

Arithmetic is performed by built-in predicates which take as arguments arithmetic expressions (see `arithexpression/1`) and evaluate them. Terms representing arithmetic expressions can be created dynamically, but at the time of evaluation, each variable in an arithmetic expression must be bound to a non-variable expression (the term must be ground). For example, given the code in the first line a possible shell interaction follows:

```
evaluate(Expression, Answer) :- Answer is Expression.

?- _X=24*9, evaluate(_X+6, Ans).

Ans = 222 ?

yes
```

20.1 Usage and interface (`arithmetic`)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `is/2`, `</2`, `=</2`, `>/2`, `>=/2`, `=:=/2`, `=\=/2`.
  - *Regular Types:*
    `arithexpression/1`.

20.2 Documentation on exports (`arithmetic`)

is/2: PREDICATE

`Val is Exp`

The arithmetic expression `Exp` is evaluated and the result is unified with `Val`

Usage 2: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `Val` is any term. (`basic_props:term/1`)
- *The following properties should hold at call time:*
  `Exp` is an arithmetic expression. (`arithmetic:arithexpression/1`)
- *The following properties hold upon exit:*
  `Val` is any term. (`basic_props:term/1`)

</2: PREDICATE

`Exp1 < Exp2`

The numeric value of `Exp1` is less than the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Exp1` is an arithmetic expression. (`arithmetic:arithexpression/1`)

`Exp2` is an arithmetic expression. (`arithmetic:arithexpression/1`)

=</2: PREDICATE

`Exp1 =< Exp2`

The numeric value of `Exp1` is less than or equal to the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Exp1` is an arithmetic expression. (`arithmetic:arithexpression/1`)

`Exp2` is an arithmetic expression. (`arithmetic:arithexpression/1`)

>/2: PREDICATE

`Exp1 > Exp2`

The numeric value of `Exp1` is greater than the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Exp1` is an arithmetic expression. (`arithmetic:arithexpression/1`)

`Exp2` is an arithmetic expression. (`arithmetic:arithexpression/1`)

>=/2: PREDICATE

`Exp1 >= Exp2`

The numeric value of `Exp1` is greater than or equal to the numeric value of `Exp2` when both are evaluated as arithmetic expressions.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Exp1` is an arithmetic expression. (`arithmetic:arithexpression/1`)

`Exp2` is an arithmetic expression. (`arithmetic:arithexpression/1`)

=:=/2: PREDICATE

`Exp1 =:= Exp2`

The numeric values of `Exp1` and `Exp2` are equal when both are evaluated as arithmetic expressions.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Exp1` is an arithmetic expression. (`arithmetic:arithexpression/1`)

`Exp2` is an arithmetic expression. (`arithmetic:arithexpression/1`)

=\=/2: PREDICATE

`Exp1 =\= Exp2`

The numeric values of `Exp1` and `Exp2` are not equal when both are evaluated as arithmetic expressions.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Exp1` is an arithmetic expression. (`arithmetic:arithexpression/1`)

`Exp2` is an arithmetic expression. (`arithmetic:arithexpression/1`)

arithexpression/1: REGTYPE

An arithmetic expression is a term built from numbers and evaluable functors that represent arithmetic functions. An arithmetic expression evaluates to a number, which may be an integer (`int/1`) or a float (`flt/1`). The evaluable functors allowed in an arithmetic expression are listed below, together with an indication of the functions they represent. All evaluable functors defined in ISO-Prolog are implemented, as well as some other useful or traditional. Unless stated otherwise, an expression evaluates to a float if any of its arguments is a float, otherwise to an integer.

- `- /1`: sign reversal. ⟨• ISO •⟩
- `+ /1`: identity.
- `-- /1`: decrement by one.
- `++ /1`: increment by one.
- `+ /2`: addition. ⟨• ISO •⟩
- `- /2`: subtraction. ⟨• ISO •⟩
- `* /2`: multiplication. ⟨• ISO •⟩
- `// /2`: integer division. Float arguments are truncated to integers, result always integer. ⟨• ISO •⟩
- `/ /2`: division. Result always float. ⟨• ISO •⟩
- `rem/2`: integer remainder. The result is always an integer, its sign is the sign of the first argument. ⟨• ISO •⟩
- `mod/2`: modulo. The result is always a positive integer. ⟨• ISO •⟩
- `abs/1`: absolute value. ⟨• ISO •⟩
- `sign/1`: sign of. ⟨• ISO •⟩
- `float_integer_part/1`: float integer part. Result always float. ⟨• ISO •⟩
- `float_fractional_part/1`: float fractional part. Result always float. ⟨• ISO •⟩
- `truncate/1`: The result is the integer equal to the integer part of the argument. ⟨• ISO •⟩
- `integer/1`: same as `truncate/1`.
- `float/1`: conversion to float. ⟨• ISO •⟩
- `floor/1`: largest integer not greater than. ⟨• ISO •⟩
- `round/1`: integer nearest to. ⟨• ISO •⟩
- `ceiling/1`: smallest integer not smaller than. ⟨• ISO •⟩
- `** /2`: exponentiation. Result always float. ⟨• ISO •⟩
- `>> /2`: integer bitwise right shift. ⟨• ISO •⟩
- `<< /2`: integer bitwise left shift. ⟨• ISO •⟩
- `/\ /2`: integer bitwise and. ⟨• ISO •⟩

- `\/ /2`: integer bitwise or. ⟨• ISO •⟩
- `\ /1`: integer bitwise complement. ⟨• ISO •⟩
- `# /2`: integer bitwise exclusive or (xor).
- `exp/1`: exponential (e to the power of). Result always float. ⟨• ISO •⟩
- `log/1`: natural logarithm (base e). Result always float. ⟨• ISO •⟩
- `sqrt/1`: square root. Result always float. ⟨• ISO •⟩
- `sin/1`: sine. Result always float. ⟨• ISO •⟩
- `cos/1`: cosine. Result always float. ⟨• ISO •⟩
- `atan/1`: arc tangent. Result always float. ⟨• ISO •⟩
- `gcd/2`: Greatest common divisor. Arguments must evaluate to integers, result always integer.

In addition to these functors, a list of just a number evaluates to this number. Since a quoted string is just a list of integers, this allows a quoted character to be used in place of its ASCII code; e.g. `"A"` behaves within arithmetic expressions as the integer 65. Note that this is not ISO-compliant, and that can be achieved by using the ISO notation `0'A`.

Arithmetic expressions, as described above, are just data structures. If you want one evaluated you must pass it as an argument to one of the arithmetic predicates defined in this library.

Usage 1: `arithexpression(E)`

– *Description:* `E` is an arithmetic expression.

Usage 2: `arithexpression(E)`

– *Description:* `E` is an arithmetic expression.

21 Basic file/stream handling

Author(s): Daniel Cabeza, Mats Carlsson.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#47 (2001/1/22, 10:24:23 CET)

This module provides basic predicates for handling files and streams, in order to make input/output on them.

21.1 Usage and interface (streams_basic)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `open/3`, `close/1`, `set_input/1`, `current_input/1`, `set_output/1`, `current_output/1`, `character_count/2`, `line_count/2`, `line_position/2`, `flush_output/1`, `flush_output/0`, `clearerr/1`, `current_stream/3`, `stream_code/2`, `absolute_file_name/2`, `absolute_file_name/7`.
  - *Regular Types:*
    `sourcename/1`, `stream/1`, `stream_alias/1`, `io_mode/1`.
  - *Multifiles:*
    `file_search_path/2`, `library_directory/1`.

21.2 Documentation on exports (streams_basic)

open/3: PREDICATE

`open(File,Mode,Stream)`

Open `File` with mode `Mode` and return in `Stream` the stream associated with the file. No extension is implicit in `File`.

Usage 1: `open(+sourcename,+io_mode,?stream)` ⟨• ISO •⟩

- *Description:* Normal use.

Usage 2: `open(+int,+io_mode,?stream)`

- *Description:* In the special case that `File` is an integer, it is assumed to be a file descriptor passed to Prolog from a foreign function call. The file descriptor is connected to a Prolog stream (invoking the UNIX function `fdopen`) which is unified with `Stream`.

Usage 3: ⟨• ISO •⟩

- *Description:* Normal use.
- *Calls should, and exit will be compatible with:*
  `Stream` is an open stream. (`streams_basic:stream/1`)
- *The following properties should hold at call time:*
  `File` is a source name. (`streams_basic:sourcename/1`)
  `Mode` is an opening mode ('read', 'write' or 'append'). (`streams_basic:io_mode/1`)

– *The following properties hold upon exit:*

`Stream` is an open stream. (`streams_basic:stream/1`)

Usage 4:

– *Description:* In the special case that `File` is an integer, it is assumed to be a file descriptor passed to Prolog from a foreign function call. The file descriptor is connected to a Prolog stream (invoking the UNIX function `fdopen`) which is unified with `Stream`.

– *Calls should, and exit will be compatible with:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties should hold at call time:*

`File` is an integer. (`basic_props:int/1`)

`Mode` is an opening mode ('read', 'write' or 'append'). (`streams_basic:io_mode/1`)

– *The following properties hold upon exit:*

`Stream` is an open stream. (`streams_basic:stream/1`)

close/1: PREDICATE

`close(Stream)`

Close the stream `Stream`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

set_input/1: PREDICATE

`set_input(Stream)`

Set the current input stream to `Stream`. A notion of *current input stream* is maintained by the system, so that input predicates with no explicit stream operate on the current input stream. Initially it is set to `user_input`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

current_input/1: PREDICATE

`current_input(Stream)`

Unify `Stream` with the current input stream.

Usage 2: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Stream` is an open stream. (`streams_basic:stream/1`)

set_output/1: PREDICATE

`set_output(Stream)`

Set the current output stream to `Stream`. A notion of *current output stream* is maintained by the system, so that output predicates with no explicit stream operate on the current output stream. Initially it is set to `user_output`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

current_output/1: PREDICATE

`current_output(Stream)`

Unify `Stream` with the current output stream.

Usage 2: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Stream` is an open stream. (`streams_basic:stream/1`)

character_count/2: PREDICATE

`character_count(Stream,Count)`

`Count` characters have been read from or written to `Stream`.

Usage 2:

– *Calls should, and exit will be compatible with:*

`Count` is an integer. (`basic_props:int/1`)

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Count` is an integer. (`basic_props:int/1`)

line_count/2: PREDICATE

`line_count(Stream,Count)`

`Count` lines have been read from or written to `Stream`.

Usage 2:

– *Calls should, and exit will be compatible with:*

`Count` is an integer. (`basic_props:int/1`)

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Count` is an integer. (`basic_props:int/1`)

line_position/2: PREDICATE

`line_position(Stream,Count)`

`Count` characters have been read from or written to the current line of `Stream`.

Usage 2:

– *Calls should, and exit will be compatible with:*

`Count` is an integer. (`basic_props:int/1`)

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Count` is an integer. (`basic_props:int/1`)

flush_output/1: PREDICATE

`flush_output(Stream)`

Flush any buffered data to output stream `Stream`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

flush_output/0: PREDICATE

`flush_output`

Behaves like `current_output(S), flush_output(S)`

clearerr/1: PREDICATE

`clearerr(Stream)`

Clear the end-of-file and error indicators for input stream `Stream`.

Usage 2:

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

current_stream/3: PREDICATE

`current_stream(Filename,Mode,Stream)`

`Stream` is a stream which was opened in mode `Mode` and which is connected to the absolute file name `Filename` (an atom) or to the file descriptor `Filename` (an integer). This predicate can be used for enumerating all currently open streams through backtracking.

Usage 3:

– *Calls should, and exit will be compatible with:*

`Filename` is an atom. (`basic_props:atm/1`)

`Mode` is an opening mode ('read', 'write' or 'append'). (`streams_basic:io_mode/1`)

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Filename` is an atom. (`basic_props:atm/1`)

`Mode` is an opening mode ('read', 'write' or 'append'). (`streams_basic:io_mode/1`)

`Stream` is an open stream. (`streams_basic:stream/1`)

Usage 4:

– *Calls should, and exit will be compatible with:*

`Filename` is an integer. (`basic_props:int/1`)

`Mode` is an opening mode ('read', 'write' or 'append'). (`streams_basic:io_mode/1`)

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Filename` is an integer. (`basic_props:int/1`)

`Mode` is an opening mode ('read', 'write' or 'append'). (`streams_basic:io_mode/1`)

`Stream` is an open stream. (`streams_basic:stream/1`)

stream_code/2: PREDICATE

`stream_code(Stream,StreamCode)`

`StreamCode` is the file descriptor (an integer) corresponding to the Prolog stream `Stream`.

Usage 3:

– *Calls should, and exit will be compatible with:*

`StreamCode` is an integer. (`basic_props:int/1`)

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`StreamCode` is an integer. (`basic_props:int/1`)

Usage 4:

– *The following properties should hold at call time:*

`Stream` is a free variable. (`term_typing:var/1`)

`StreamCode` is an integer. (`basic_props:int/1`)

– *The following properties hold upon exit:*

`Stream` is an open stream. (`streams_basic:stream/1`)

absolute_file_name/2: PREDICATE

`absolute_file_name(RelFileSpec,AbsFileSpec)`

If `RelFileSpec` is an absolute pathname then do an absolute lookup. If `RelFileSpec` is a relative pathname then prefix the name with the name of the current directory and do an absolute lookup. If `RelFileSpec` is a path alias, perform the lookup following the path alias rules (see `sourcename/1`). In all cases: if a matching file with suffix `.pl` exists, then `AbsFileSpec` will be unified with this file. Failure to open a file normally causes an exception. The behaviour can be controlled by the `fileerrors` prolog flag.

Usage 1: `absolute_file_name(+RelFileSpec,-AbsFileSpec)`

– *Description:* `AbsFileSpec` is the absolute name (with full path) of `RelFileSpec`.

– *Calls should, and exit will be compatible with:*

`+RelFileSpec` is a source name. (`streams_basic:sourcename/1`)

`-AbsFileSpec` is an atom. (`basic_props:atm/1`)

Usage 2: `absolute_file_name(RelFileSpec,AbsFileSpec)`

– *Description:* `AbsFileSpec` is the absolute name (with full path) of `RelFileSpec`.

– *Calls should, and exit will be compatible with:*

`RelFileSpec` is a source name. (`streams_basic:sourcename/1`)

`AbsFileSpec` is an atom. (`basic_props:atm/1`)

– *The following properties should hold at call time:*

`RelFileSpec` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

`AbsFileSpec` is a free variable. (`term_typing:var/1`)

absolute_file_name/7: PREDICATE

`absolute_file_name(Spec,Opt,Suffix,CurrDir,AbsFile,AbsBase,AbsDir)`

`AbsFile` is the absolute name (with full path) of `Spec`, which has an optional first suffix `Opt` and an optional second suffix `Suffix`, when the current directory is `CurrDir`. `AbsBase` is the same as `AbsFile`, but without the second suffix, and `AbsDir` is the absolute path of the directory where `AbsFile` is. The Ciao compiler invokes this predicate with `Opt='_opt'` and `Suffix='.pl'` when searching source files.

Usage 2:

– *The following properties should hold at call time:*

`Spec` is a source name. (`streams_basic:sourcename/1`)

`Opt` is an atom. (`basic_props:atm/1`)

`Suffix` is an atom. (`basic_props:atm/1`)

`CurrDir` is an atom. (`basic_props:atm/1`)

`AbsFile` is a free variable. (`term_typing:var/1`)

`AbsBase` is a free variable. (`term_typing:var/1`)

`AbsDir` is a free variable. (`term_typing:var/1`)

– *The following properties hold upon exit:*

`AbsFile` is an atom. (`basic_props:atm/1`)

`AbsBase` is an atom. (`basic_props:atm/1`)

`AbsDir` is an atom. (`basic_props:atm/1`)

sourcename/1: REGTYPE

A source name is a flexible way of referring to a concrete file. A source name is either a relative or absolute filename given as:

- an atom, or
- a unary functor (which represents a *path alias*, see below) applied to a *relative* path, the latter being given as an atom.

In all cases certain filename extensions (e.g., `.pl`) can be implicit. In the first form above, file names can be relative to the current directory. Also, file names beginning with `~` or `$` are treated specially. For example,

`'~/ciao/sample.pl'`
: is equivalent to `'/home/staff/herme/ciao/sample.pl'`, if `/home/staff/herme` is the user's home directory. (This is also equivalent to `'$HOME/ciao/sample.pl'` as explained below.)

`'~bardo/prolog/sample.pl'`
: is equivalent to `'/home/bardo/prolog/sample.pl'`, if `/home/bardo` is bardo's home directory.

`'$UTIL/sample.pl'`
: is equivalent to `'/usr/local/src/utilities/sample.pl'`, if `/usr/local/src/utilities` is the value of the environment variable `UTIL`.

The second form allows using path aliases. Such aliases allow refering to files not with absolute file system paths but with paths which are relative to predefined (or user-defined) abstract names. For example, given the path alias `myutils` which has been defined to refer to path `'/home/bardo/utilities'`, if that directory contains the file `stuff.pl` then the term `myutils(stuff)` in a `use_module/1` declaration would refer to the file `'/home/bardo/utilities/stuff.pl'` (the `.pl` extension is implicit in the `use_module/1` declaration). As a special case, if that directory contains a subdirectory named `stuff` which in turn contains the file `stuff.pl`, the same term would refer to the file `'/home/bardo/utilities/stuff/stuff.pl'`. If a path alias is related to several paths, all paths are scanned in sequence until a match is found. For information on predefined path aliases or how to define new path aliases, see `file_search_path/2`.

Usage 1: `sourcename(F)`

– *Description:* `F` is a source name.

Usage 2: `sourcename(F)`

– *Description:* `F` is a source name.

stream/1: REGTYPE

Streams correspond to the file pointers used at the operating system level, and usually represent opened files. There are four special streams which correspond with the operating system standard streams:

`user_input`
: The standard input stream, i.e. the terminal, usually.

`user_output`
: The standard output stream, i.e. the terminal, usually.

`user_error`
: The standard error stream.

`user`
: The standard input or output stream, depending on context.

Usage 1: `stream(S)`

– *Description:* `S` is an open stream.

Usage 2: `stream(S)`

– *Description:* `S` is an open stream.

stream_alias/1: REGTYPE

Usage 1: `stream_alias(S)`

– *Description:* `S` is the alias of an open stream, i.e., an atom which represents a stream at Prolog level.

Usage 2: `stream_alias(S)`

– *Description:* `S` is the alias of an open stream, i.e., an atom which represents a stream at Prolog level.

io_mode/1: REGTYPE

Can have the following values:

`read` Open the file for input.

`write` Open the file for output. The file is created if it does not already exist, the file will otherwise be truncated.

`append` Open the file for output. The file is created if it does not already exist, the file will otherwise be appended to.

Usage 1: `io_mode(M)`

– *Description:* `M` is an opening mode ('read', 'write' or 'append').

Usage 2: `io_mode(M)`

– *Description:* `M` is an opening mode ('read', 'write' or 'append').

21.3 Documentation on multifiles (`streams_basic`)

file_search_path/2: PREDICATE

`file_search_path(Alias,Path)`

The path alias `Alias` is linked to path `Path`. Both arguments must be atoms. New facts (or clauses) of this predicate can be asserted to define new path aliases. Predefined path aliases in Ciao are:

`library` Initially points to all Ciao library paths. See `library_directory/1`.

`engine` The path of the Ciao engine builtins.

`.` The current path (`'.'`).

The predicate is *multifile*.

The predicate is of type *dynamic*.

library_directory/1: PREDICATE

`library_directory(Path)`

`Path` is a library path (a path represented by the path alias `library`). Predefined library paths in Ciao are `'$CIAOLIB/lib'`, `'$CIAOLIB/library'`, and `'$CIAOLIB/contrib'`, given that `$CIAOLIB` is the path of the root ciao library directory. More library paths can be defined by asserting new facts (or clauses) of this predicate.

The predicate is *multifile*.

The predicate is of type *dynamic*.

22 Basic input/output

Author(s): Daniel Cabeza, Mats Carlsson.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

This module provides predicates for character input/output and for canonical term output. From the ISO-Prolog predicates for character input/output, only the `_code` versions are provided, the rest are given by `library(iso_byte_char)`, using these. Most predicates are provided in two versions: one that specifies the input or output stream as the first argument and a second which omits this argument and uses the current input or output stream.

22.1 Usage and interface (`io_basic`)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `get_code/2`, `get_code/1`, `get1_code/2`, `get1_code/1`, `peek_code/2`, `peek_code/1`, `skip_code/2`, `skip_code/1`, `put_code/2`, `put_code/1`, `nl/1`, `nl/0`, `tab/2`, `tab/1`, `code_class/2`, `getct/2`, `getct1/2`, `display/2`, `display/1`, `displayq/2`, `displayq/1`.

22.2 Documentation on exports (`io_basic`)

get_code/2: PREDICATE

`get_code(Stream,Code)`

Reads from `Stream` the next character and unifies `Code` with its character code. At end of stream, unifies `Code` with the integer -1.

Usage 2: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `Code` is an integer. (`basic_props:int/1`)
- *The following properties should hold at call time:*
  `Stream` is an open stream. (`streams_basic:stream/1`)
- *The following properties hold upon exit:*
  `Code` is an integer. (`basic_props:int/1`)

get_code/1: PREDICATE

`get_code(Code)`

Behaves like `current_input(S), get_code(S,Code)`.

Usage 2: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `Code` is an integer. (`basic_props:int/1`)
- *The following properties hold upon exit:*
  `Code` is an integer. (`basic_props:int/1`)

get1_code/2: PREDICATE

`get1_code(Stream,Code)`

Reads from `Stream` the next non-layout character (see `code_class/2`) and unifies `Code` with its character code. At end of stream, unifies `Code` with the integer -1.

Usage 2:

– *Calls should, and exit will be compatible with:*

`Code` is an integer. (`basic_props:int/1`)

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Code` is an integer. (`basic_props:int/1`)

get1_code/1: PREDICATE

`get1_code(Code)`

Behaves like `current_input(S), get1_code(S,Code)`.

Usage 2:

– *Calls should, and exit will be compatible with:*

`Code` is an integer. (`basic_props:int/1`)

– *The following properties hold upon exit:*

`Code` is an integer. (`basic_props:int/1`)

peek_code/2: PREDICATE

`peek_code(Stream,Code)`

Unifies `Code` with the character code of the next character of `Stream`, leaving the stream position unaltered. At end of stream, unifies `Code` with the integer -1.

Usage 2: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`Code` is an integer. (`basic_props:int/1`)

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

– *The following properties hold upon exit:*

`Code` is an integer. (`basic_props:int/1`)

peek_code/1: PREDICATE

`peek_code(Code)`

Behaves like `current_input(S), peek_code(S,Code)`.

Usage 2: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`Code` is an integer. (`basic_props:int/1`)

– *The following properties hold upon exit:*

`Code` is an integer. (`basic_props:int/1`)

skip_code/2: PREDICATE

`skip_code(Stream,Code)`

Skips just past the next character code `Code` from `Stream`.

Usage 2:

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

`Code` is an integer. (`basic_props:int/1`)

skip_code/1: PREDICATE

`skip_code(Code)`

Behaves like `current_input(S), skip_code(S,Code)`.

Usage 2:

– *The following properties should hold at call time:*

`Code` is an integer. (`basic_props:int/1`)

put_code/2: PREDICATE

`put_code(Stream,Code)`

Outputs to `Stream` the character corresponding to character code `Code`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

`Code` is an integer. (`basic_props:int/1`)

put_code/1: PREDICATE

`put_code(Code)`

Behaves like `current_output(S), put_code(S,Code)`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Code` is an integer. (`basic_props:int/1`)

nl/1: PREDICATE

`nl(Stream)`

Outputs a newline character to `Stream`. Equivalent to `put_code(Stream, 0'\n)`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

nl/0: PREDICATE

`nl`

Behaves like `current_output(S), nl(S)`.

tab/2: PREDICATE

`tab(Stream,Num)`

Outputs `Num` spaces to `Stream`.

Usage 2:

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

`Num` is an integer. (`basic_props:int/1`)

tab/1: PREDICATE

`tab(Num)`

Behaves like `current_output(S), tab(S,Num)`.

Usage 2:

– *The following properties should hold at call time:*

`Num` is an integer. (`basic_props:int/1`)

code_class/2: PREDICATE

`code_class(Code,Class)`

Unifies `Class` with an integer corresponding to the lexical class of the character whose code is `Code`, with the following correspondence:

```
0 - layout (includes space, newline, tab)
1 - small letter
2 - capital letter (including '_')
3 - digit
4 - graphic (includes #$&*+-./:<=>?@^\`~ )
5 - punctuation (includes !;"'%(),[]{|} )
```

Note that in ISO-Prolog the back quote ` is a punctuation character, whereas in Ciao it is a graphic character. Thus, if compatibility with ISO-Prolog is desired, the programmer should not use this character in unquoted names.

Usage 2:

– *Calls should, and exit will be compatible with:*

`Class` is an integer. (`basic_props:int/1`)

– *The following properties should hold at call time:*

`Code` is an integer. (`basic_props:int/1`)

– *The following properties hold upon exit:*

`Class` is an integer. (`basic_props:int/1`)

getct/2: PREDICATE

`getct(Code,Type)`

Reads from the current input stream the next character, unifying `Code` with its character code, and `Type` with its lexical class. At end of stream, unifies both `Code` and `Type` with the integer -1. Equivalent to

```
get(Code), (Code = -1 -> Type = -1 ; code_class(Code,Type))
```

Usage 2:

– *Calls should, and exit will be compatible with:*

`Code` is an integer. (`basic_props:int/1`)

`Type` is an integer. (`basic_props:int/1`)

– *The following properties hold upon exit:*

`Code` is an integer. (`basic_props:int/1`)

`Type` is an integer. (`basic_props:int/1`)

getct1/2: PREDICATE

`getct1(Code,Type)`

Reads from the current input stream the next non-layout character, unifying `Code` with its character code, and `Type` with its lexical class (which will be nonzero). At end of stream, unifies both `Code` and `Type` with the integer -1. Equivalent to

```
get1(Code), (Code = -1 -> Type = -1 ; code_class(Code,Type))
```

Usage 2:

– *Calls should, and exit will be compatible with:*

`Code` is an integer. (`basic_props:int/1`)

`Type` is an integer. (`basic_props:int/1`)

– *The following properties hold upon exit:*

`Code` is an integer. (`basic_props:int/1`)

`Type` is an integer. (`basic_props:int/1`)

display/2: PREDICATE

`display(Stream,Term)`

Displays `Term` onto `Stream`. Lists are output using list notation, the other compound terms are output in functional notation. Similar to `write_term(Stream, Term, [ignore_ops(ops)])`, except that curly bracketed notation is not used with `{}/1`, and the `write_strings` flag is not honored.

Usage 2:

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold globally:*

`Term` is not further instantiated. (`basic_props:not_further_inst/2`)

display/1: PREDICATE

`display(Term)`

Behaves like `current_output(S), display(S,Term).`

Usage 2:

– *The following properties should hold at call time:*

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold globally:*

`Term` is not further instantiated. (`basic_props:not_further_inst/2`)

displayq/2: PREDICATE

`displayq(Stream,Term)`

Similar to `display(Stream, Term)`, but atoms and functors that can't be read back by `read_term/3` are quoted. Thus, similar to `write_term(Stream, Term, [quoted(true), ignore_ops(ops)])`, with the same exceptions as `display/2`.

Usage 2:

– *The following properties should hold at call time:*

`Stream` is an open stream. (`streams_basic:stream/1`)

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold globally:*

`Term` is not further instantiated. (`basic_props:not_further_inst/2`)

displayq/1: PREDICATE

`displayq(Term)`

Behaves like `current_output(S), displayq(S,Term).`

Usage 2:

– *The following properties should hold at call time:*

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

`Term` is any term. (`basic_props:term/1`)

– *The following properties hold globally:*

`Term` is not further instantiated. (`basic_props:not_further_inst/2`)

23 Exception handling

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#107 (2001/5/31, 14:12:58 CEST)
This module includes predicates related to exceptions, which alter the normal flow of Prolog.

23.1 Usage and interface (exceptions)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `catch/3`, `intercept/3`, `throw/1`, `halt/0`, `halt/1`.

23.2 Documentation on exports (exceptions)

catch/3: PREDICATE

`catch(Goal,Error,Handler)`

Executes `Goal`. If an exception is raised during its execution, `Error` is unified with the exception, and if the unification succeeds, the entire execution derived from `Goal` is aborted, and `Handler` is executed. The execution resumes with the continuation of the catch/3 call. For example, given the code

```
p(X) :- throw(error), display('---').
p(X) :- display(X).
```

the execution of `"catch(p(0), E, display(E)), display(.), fail."` results in the output `"error."`.

Meta-predicate with arguments: `catch(goal,?,goal)`.

Usage 2: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `Error` is any term. (`basic_props:term/1`)
- *The following properties should hold at call time:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)
  `Handler` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)
- *The following properties hold upon exit:*
  `Error` is any term. (`basic_props:term/1`)

intercept/3: PREDICATE

`intercept(Goal,Error,Handler)`

Executes `Goal`. If an exception is raised during its execution, `Error` is unified with the exception, and if the unification succeeds, `Handler` is executed and then the execution resumes after the predicate which produced the exception. Note the difference with

builtin `catch/3`, given the same code defined there, the execution of `"intercept(p(0), E, display(E)), display(.), fail."` results in the output `"error---.0."`.

Meta-predicate with arguments: `intercept(goal,?,goal)`.

Usage 2:

– *Calls should, and exit will be compatible with:*

`Error` is any term. (`basic_props:term/1`)

– *The following properties should hold at call time:*

`Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Handler` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

– *The following properties hold upon exit:*

`Error` is any term. (`basic_props:term/1`)

throw/1: PREDICATE

`throw(Ball)`

Raises an error, throwing the exception `Ball`, to be caught by an ancestor `catch/3` or `intercept/3`. The closest matching ancestor is chosen. Exceptions are also thrown by other builtins in case of error.

Usage 1: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`Ball` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

Usage 2: ⟨• ISO •⟩

– *Calls should, and exit will be compatible with:*

`Ball` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

halt/0: PREDICATE

`halt`

Halt the system, exiting to the invoking shell.

halt/1: PREDICATE

`halt(Code)`

Halt the system, exiting to the invoking shell, returning exit code `Code`.

Usage 2: ⟨• ISO •⟩

– *The following properties should hold at call time:*

`Code` is an integer. (`basic_props:int/1`)

abort/0: PREDICATE

`abort`

Abort the current execution.

24 Changing system behaviour and various flags

Author(s): Daniel Cabeza, Mats Carlsson.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#213 (2002/5/14, 18:11:29 CEST)

Flags define some parameters of the system and control the behavior of system or library predicates. Each flag has a name and an associated predefined value, and except some system flags which are fixed in general their associated value is changeable. Predefined flags in the system are:

`version` The Ciao version, as a term `ciao(Version,Patch)`. `Version` is a floating point number, `Patch` is an integer. Unchangeable.

`argv` Its value is a list of atoms representing the program arguments supplied when the current executable was invoked. This is the value to which is instantiated the argument of the `main/1` predicate at executable startup. Unchangeable.

`bounded` It is `false`, to denote that the range of integers can be considered infinite (but see `int/1`). Unchangeable. ⟨• ISO •⟩

`fileerrors`
If `on`, predicates handling files give errors (throw exceptions) when a file is inexistent or an operation is not allowed. If `off`, fail in that conditions. Initially `on`.

`gc` Controls whether garbage collection is done. May be `on` (default) or `off`.

`gc_margin`
An integer `Margin`. If less than `Margin` kilobytes are reclaimed in a garbage collection then the size of the garbage collected area should be increased. Also, no garbage collection is attempted unless the garbage collected area has at least `Margin` kilobytes. Initially 500.

`gc_trace` Governs garbage collection trace messages. An element off `[on,off,terse,verbose]`. Initially `off`.

`integer_rounding_function`
It is `toward_zero`, so that `-1 =:= -3//2` succeeds. Unchangeable. ⟨• ISO •⟩

`max_arity`
It is 255, so that no compound term (or predicate) can have more than this number of arguments. Unchangeable. ⟨• ISO •⟩

`quiet` Controls which messages issued using `io_aux` are actually written. As the system uses that library to report its messages, this flag controls the *verbosity* of the system. Possible states of the flag are:

- `on` No messages are reported.
- `error` Only error messages are reported.
- `warning` Only error and warning messages are reported.
- `off` All messages are reported, except debug messages. This is the default state.
- `debug` All messages, including debug messages, are reported. This is only intended for the system implementators.

`unknown` Controls action on calls to undefined predicates. The possible states of the flag are:

- `error` An error is thrown with the error term `existence_error(procedure, F/A)`.

`fail` The call simply fails.

`warning` A warning is written and the call fails.

The state is initially `error`. ⟨• ISO •⟩

24.1 Usage and interface (prolog_flags)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `set_prolog_flag/2`, `current_prolog_flag/2`, `prolog_flag/3`, `push_prolog_flag/2`, `pop_prolog_flag/1`, `prompt/2`, `gc/0`, `nogc/0`, `fileerrors/0`, `nofileerrors/0`.
  - *Multifiles:*
    `define_flag/3`.

24.2 Documentation on exports (prolog_flags)

set_prolog_flag/2: PREDICATE

`set_prolog_flag(FlagName,Value)`

Set existing flag `FlagName` to `Value`.

Usage 2: ⟨• ISO •⟩

- *The following properties should hold at call time:*
  `FlagName` is an atom. (`basic_props:atm/1`)
  `Value` is any term. (`basic_props:term/1`)

current_prolog_flag/2: PREDICATE

`current_prolog_flag(FlagName,Value)`

`FlagName` is an existing flag and `Value` is the value currently associated with it.

Usage 2: ⟨• ISO •⟩

- *Calls should, and exit will be compatible with:*
  `FlagName` is an atom. (`basic_props:atm/1`)
  `Value` is any term. (`basic_props:term/1`)
- *The following properties hold upon exit:*
  `FlagName` is an atom. (`basic_props:atm/1`)
  `Value` is any term. (`basic_props:term/1`)

prolog_flag/3: PREDICATE

`prolog_flag(FlagName,OldValue,NewValue)`

`FlagName` is an existing flag, unify `OldValue` with the value associated with it, and set it to new value `NewValue`.

Usage 2: `prolog_flag(?FlagName,-OldValue,-NewValue)`

– *Description:* Same as `current_prolog_flag(FlagName, OldValue)`
– *The following properties should hold at call time:*
`FlagName` is an atom. (`basic_props:atm/1`)
The terms `OldValue` and `NewValue` are strictly identical. (`term_compare:== /2`)

Usage 3:
– *Calls should, and exit will be compatible with:*
`FlagName` is an atom. (`basic_props:atm/1`)
`OldValue` is any term. (`basic_props:term/1`)
– *The following properties should hold at call time:*
`NewValue` is any term. (`basic_props:term/1`)
– *The following properties hold upon exit:*
`FlagName` is an atom. (`basic_props:atm/1`)
`OldValue` is any term. (`basic_props:term/1`)

Usage 4: `prolog_flag(FlagName,OldValue,NewValue)`
– *Description:* Same as `current_prolog_flag(FlagName, OldValue)`
– *The following properties should hold at call time:*
`OldValue` is a free variable. (`term_typing:var/1`)
`NewValue` is a free variable. (`term_typing:var/1`)
`FlagName` is an atom. (`basic_props:atm/1`)
The terms `OldValue` and `NewValue` are strictly identical. (`term_compare:== /2`)

push_prolog_flag/2: PREDICATE

`push_prolog_flag(Flag,NewValue)`

Same as `set_prolog_flag/2`, but storing current value of `Flag` to restore it with `pop_prolog_flag/1`.

Usage 2:
– *The following properties should hold at call time:*
`Flag` is an atom. (`basic_props:atm/1`)
`NewValue` is any term. (`basic_props:term/1`)

pop_prolog_flag/1: PREDICATE

`pop_prolog_flag(Flag)`

Restore the value of `Flag` previous to the last non-canceled `push_prolog_flag/2` on it.

Usage 2:
– *The following properties should hold at call time:*
`Flag` is an atom. (`basic_props:atm/1`)

prompt/2: PREDICATE

`prompt(Old,New)`

Unify `Old` with the current prompt for reading, change it to `New`.

Usage 2: `prompt(Old,New)`

– *Description:* Unify `Old` with the current prompt for reading without changing it.
– *The following properties should hold at call time:*
`Old` is a free variable. (`term_typing:var/1`)
`New` is a free variable. (`term_typing:var/1`)
The terms `Old` and `New` are strictly identical. (`term_compare:== /2`)
– *The following properties hold upon exit:*
`Old` is an atom. (`basic_props:atm/1`)
`New` is an atom. (`basic_props:atm/1`)

Usage 3:
– *Calls should, and exit will be compatible with:*
`Old` is an atom. (`basic_props:atm/1`)
– *The following properties should hold at call time:*
`New` is an atom. (`basic_props:atm/1`)
– *The following properties hold upon exit:*
`Old` is an atom. (`basic_props:atm/1`)

Usage 4: `prompt(Old,New)`
– *Description:* Unify `Old` with the current prompt for reading without changing it.
– *The following properties should hold at call time:*
`Old` is a free variable. (`term_typing:var/1`)
`New` is a free variable. (`term_typing:var/1`)
The terms `Old` and `New` are strictly identical. (`term_compare:== /2`)
– *The following properties hold upon exit:*
`Old` is an atom. (`basic_props:atm/1`)
`New` is an atom. (`basic_props:atm/1`)

gc/0: PREDICATE

Usage 1:
– *Description:* Enable garbage collection. Equivalent to `set_prolog_flag(gc, on)`

Usage 2:
– *Description:* Enable garbage collection. Equivalent to `set_prolog_flag(gc, on)`

nogc/0: PREDICATE

Usage 1:
– *Description:* Disable garbage collection. Equivalent to `set_prolog_flag(gc, off)`

Usage 2:
– *Description:* Disable garbage collection. Equivalent to `set_prolog_flag(gc, off)`

fileerrors/0: PREDICATE

Usage 1:
– *Description:* Enable reporting of file errors. Equivalent to `set_prolog_flag(fileerrors, on)`

Usage 2:

– *Description:* Enable reporting of file errors. Equivalent to `set_prolog_flag(fileerrors, on)`

nofileerrors/0: PREDICATE

Usage 1:

– *Description:* Disable reporting of file errors. Equivalent to `set_prolog_flag(fileerrors, off)`

Usage 2:

– *Description:* Disable reporting of file errors. Equivalent to `set_prolog_flag(fileerrors, off)`

24.3 Documentation on multifiles (prolog_flags)

define_flag/3: PREDICATE

`define_flag(Flag,Values,Default)`

New flags can be defined by writing facts of this predicate. `Flag` is the name of the new flag, `Values` defines the posible values for the flag (see below) and `Default` defines the predefined value associated with the flag (which should be compatible with `Values`).

The predicate is *multifile*.

Usage 1: `define_flag(-atm,Values,-atm)`

– *Description:* Posible values for the flag are atoms.
Example:

```
:- multifile define_flag/3.
define_flag(tmpdir, atom, '/tmp').
```

– *Call and exit should be compatible with:*
The terms `Values` and `atom` are strictly identical. (`term_compare:== /2`)

Usage 2: `define_flag(-atm,Values,-int)`

– *Description:* Posible values for the flag are integers.
Example:

```
:- multifile define_flag/3.
define_flag(max_connections, integer, 10).
```

– *Call and exit should be compatible with:*
The terms `Values` and `integer` are strictly identical. (`term_compare:== /2`)

Usage 3: `define_flag(Flag,Values,Default)`

– *Description:* Posible values for the flag are the elements of `Values`.
Example:

```
:- multifile define_flag/3.
define_flag(debug, [on,debug,trace,off], off).
```

– *Call and exit should be compatible with:*
`Flag` is an atom. (`basic_props:atm/1`)
`Values` is a list. (`basic_props:list/1`)

– *The following properties should hold upon exit:*
`Default` is an element of `Values`. (`basic_props:member/2`)

25 Fast/concurrent update of facts

Author(s): Daniel Cabeza, Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#95 (2001/5/2, 12:18:6 CEST)

Prolog implementations traditionally implement the concept of dynamic predicates: predicates which can be inspected or modified at run-time, adding or deleting individual clauses. The power of this feature comes at a cost: as new clause bodies can be arbitrarily added to the program, new predicate calls can arise which are not 'visible' at compile-time, thus complicating global analysis and optimization of the code. But it is the case that most of the time what the programmer wants is simply to store data, with the purpose of sharing it between search branches, predicates, or even execution threads. In Ciao the concept of data predicate serves this purpose: a data predicate is a predicate composed exclusively by facts, which can be inspected, and dynamically added or deleted, at run-time. Using data predicates instead of normal dynamic predicates brings benefits in terms of speed, but above all makes the code much easier to analyze automatically and thus allows better optimization.

Also, a special kind of data predicates exists, *concurrent predicates*, which can be used to communicate/synchronize among different execution threads (see Chapter 78 [Low-level concurrency/multithreading primitives], page 315).

Data predicates must be declared through a `data/1` declaration. Concurrent data predicates must be declared through a `concurrent/1` declaration.

25.1 Usage and interface (data_facts)

- **Library usage:**

  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*

    `asserta_fact/1`, `asserta_fact/2`, `assertz_fact/1`, `assertz_fact/2`, `current_fact/1`, `current_fact/2`, `retract_fact/1`, `retractall_fact/1`, `current_fact_nb/1`, `retract_fact_nb/1`, `close_predicate/1`, `open_predicate/1`, `set_fact/1`, `erase/1`.

25.2 Documentation on exports (data_facts)

asserta_fact/1: PREDICATE

```
asserta_fact(Fact)
```

`Fact` is added to the corresponding data predicate. The fact becomes the first clause of the predicate concerned.

Meta-predicate with arguments: `asserta_fact(fact)`.

Usage 2:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

asserta_fact/2: PREDICATE

`asserta_fact(Fact,Ref)`

Same as `asserta_fact/1`, instantiating `Ref` to a unique identifier of the asserted fact.

Meta-predicate with arguments: `asserta_fact(fact,?)`.

Usage 2:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Ref` is a free variable. (`term_typing:var/1`)

– *The following properties hold upon exit:*

`Ref` is a reference of a dynamic or data clause. (`data_facts:reference/1`)

assertz_fact/1: PREDICATE

`assertz_fact(Fact)`

`Fact` is added to the corresponding data predicate. The fact becomes the last clause of the predicate concerned.

Meta-predicate with arguments: `assertz_fact(fact)`.

Usage 2:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

assertz_fact/2: PREDICATE

`assertz_fact(Fact,Ref)`

Same as `assertz_fact/1`, instantiating `Ref` to a unique identifier of the asserted fact.

Meta-predicate with arguments: `assertz_fact(fact,?)`.

Usage 2:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Ref` is a free variable. (`term_typing:var/1`)

– *The following properties hold upon exit:*

`Ref` is a reference of a dynamic or data clause. (`data_facts:reference/1`)

current_fact/1: PREDICATE

`current_fact(Fact)`

Gives on backtracking all the facts defined as data or concurrent which unify with `Fact`. It is faster than calling the predicate explicitly, which do invoke the meta-interpreter. If the `Fact` has been defined as concurrent and has not been closed, `current_fact/1` will wait (instead of failing) for more clauses to appear after the last clause of `Fact` is returned.

Meta-predicate with arguments: `current_fact(fact)`.

Usage 2:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

current_fact/2: PREDICATE

`current_fact(Fact,Ref)`

`Fact` is a fact of a data predicate and `Ref` is its reference identifying it uniquely.

Meta-predicate with arguments: `current_fact(fact,?)`.

Usage 1: `current_fact(+callable,-reference)`

- *Description:* Gives on backtracking all the facts defined as data which unify with `Fact`, instantiating `Ref` to a unique identifier for each fact.

Usage 2: `current_fact(?callable,+reference)`

- *Description:* Given `Ref`, unifies `Fact` with the fact identified by it.

Usage 3:

- *Description:* Gives on backtracking all the facts defined as data which unify with `Fact`, instantiating `Ref` to a unique identifier for each fact.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

  `Ref` is a free variable. (`term_typing:var/1`)
- *The following properties hold upon exit:*

  `Ref` is a reference of a dynamic or data clause. (`data_facts:reference/1`)

Usage 4:

- *Description:* Given `Ref`, unifies `Fact` with the fact identified by it.
- *Calls should, and exit will be compatible with:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)
- *The following properties should hold at call time:*

  `Ref` is a reference of a dynamic or data clause. (`data_facts:reference/1`)
- *The following properties hold upon exit:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

retract_fact/1: PREDICATE

`retract_fact(Fact)`

Unifies `Fact` with the first matching fact of a data predicate, and then erases it. On backtracking successively unifies with and erases new matching facts. If `Fact` is declared as concurrent and is non- closed, `retract_fact/1` will wait for more clauses or for the closing of the predicate after the last matching clause has been removed.

Meta-predicate with arguments: `retract_fact(fact)`.

Usage 2:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

retractall_fact/1: PREDICATE

`retractall_fact(Fact)`

Erase all the facts of a data predicate unifying with `Fact`. Even if all facts are removed, the predicate continues to exist.

Meta-predicate with arguments: `retractall_fact(fact)`.

Usage 2:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

current_fact_nb/1: PREDICATE

`current_fact_nb(Fact)`

Behaves as `current_fact/1` but a fact is never waited on even if it is concurrent and non-closed.

Meta-predicate with arguments: `current_fact_nb(fact)`.

Usage 2:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

retract_fact_nb/1: PREDICATE

`retract_fact_nb(Fact)`

Behaves as `retract_fact/1`, but never waits on a fact, even if it has been declared as concurrent and is non- closed.

Meta-predicate with arguments: `retract_fact_nb(fact)`.

Usage 2:

– *The following properties should hold at call time:*

`Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

close_predicate/1: PREDICATE

`close_predicate(Pred)`

Changes the behavior of the predicate `Pred` if it has been declared as a concurrent predicate: calls to this predicate will fail (instead of wait) if no more clauses of `Pred` are available.

Meta-predicate with arguments: `close_predicate(fact)`.

Usage 2:

– *The following properties should hold at call time:*

`Pred` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

open_predicate/1: PREDICATE

`open_predicate(Pred)`

Reverts the behavior of concurrent predicate `Pred` to waiting instead of failing if no more clauses of `Pred` are available.

Meta-predicate with arguments: `open_predicate(fact)`.

Usage 2:

- *The following properties should hold at call time:*

  `Pred` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

set_fact/1: PREDICATE

`set_fact(Fact)`

Sets `Fact` as the unique fact of the corresponding data predicate.

Meta-predicate with arguments: `set_fact(fact)`.

Usage 2:

- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

erase/1: PREDICATE

`erase(Ref)`

Deletes the clause referenced by `Ref`.

Usage 2:

- *The following properties should hold at call time:*

  `Ref` is a reference of a dynamic or data clause. (`data_facts:reference/1`)

25.3 Documentation on internals (`data_facts`)

data/1: DECLARATION

Usage: `:- data Predicates.`

- *Description:* Defines each predicate in `Predicates` as a data predicate. If a predicate is defined data in a file, it must be defined data in every file containing clauses for that predicate. The directive should precede all clauses of the affected predicates. This directive is defined as a prefix operator in the compiler.
- *The following properties hold at call time:*

  `Predicates` is a sequence or list of `prednames`. (`basic_props:sequence_or_list/2`)

concurrent/1: DECLARATION

Usage: `:- concurrent Predicates.`

- *Description:* Defines each predicate in `Predicates` as a concurrent predicate. If a predicate is defined concurrent in a file, it must be defined concurrent in every file containing clauses for that predicate. The directive should precede all clauses of the affected predicates. This directive is defined as a prefix operator in the compiler.

– *The following properties hold at call time:*
`Predicates` is a sequence or list of `prednames`. (`basic_props:sequence_or_list/2`)

reference/1: REGTYPE

Usage: `reference(R)`

– *Description:* `R` is a reference of a dynamic or data clause.

26 Extending the syntax

Author(s): Daniel Cabeza.

This chapter documents the builtin directives in Ciao for extending the syntax of source files. Note that the ISO-Prolog directive `char_conversion/2` is not implemented, since Ciao does not (yet) have a character conversion table.

26.1 Usage and interface (`syntax_extensions`)

- **Library usage:**
  These directives are builtin in Ciao, so nothing special has to be done to use them.

26.2 Documentation on internals (`syntax_extensions`)

op/3: DECLARATION

Usage: `:- op(Priority,Op_spec,Operator).` ⟨• ISO •⟩

– *Description:* Updates the operator table for reading the terms in the rest of the current text, in the same way as the builtin `op/3` does. Its scope is local to the current text. Usually included in package files.

– *The following properties hold at call time:*

`Priority` is an integer. (`basic_props:int/1`)

`Op_spec` specifies the type and associativity of an operator. (`basic_props:operator_specifier/1`)

`Operator` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

new_declaration/1: DECLARATION

Usage: `:- new_declaration(Predicate).`

– *Description:* Declares `Predicate` to be a valid declaration in the rest of the current text. Such declarations are simply ignored by the compiler or top level, but can be used by other code processing programs such as an automatic documentator. Also, they can easily translated into standard code (a set of facts and/or rules) by defining a suitable expansion (e.g., by `add_sentence_trans/1`, etc.). This is tipically done in package files.

Equivalent to `new_declaration(Predicate, off).`

– *The following properties hold at call time:*

`Predicate` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(`basic_props:predname/1`)

new_declaration/2: DECLARATION

Usage: :- `new_declaration(Predicate,In_Itf).`

- *Description:* Declares `Predicate` to be a valid declaration in the rest of the current text. Such declarations will be included in the interface file for this file if `In_Itf` is 'on', not if it is 'off'. Including such declarations in interface files makes them visible while processing other modules which make use of this one.
- *The following properties hold at call time:*

  `Predicate` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

  (`basic_props:predname/1`)

  `In_Itf` is 'on' or 'off' (`syntax_extensions:switch/1`)

load_compilation_module/1: DECLARATION

Usage: :- `load_compilation_module(File).`

- *Description:* Loads code defined in `File` into the compiler, usually including predicates which define translations of terms, for use with the declarations `add_sentence_trans/1` and similar ones. Normally included in package files.
- *The following properties hold at call time:*

  `File` is a source name. (`streams_basic:sourcename/1`)

add_sentence_trans/1: DECLARATION

Usage: :- `add_sentence_trans(Predicate).`

- *Description:* Starts a translation, defined by `Predicate`, of the terms read by the compiler in the rest of the current text. For each subsequent term read by the compiler, the translation predicate is called to obtain a new term which will be used by the compiler as if it where the term present in the file. If the call fails, the term is used as such. A list may be returned also, to translate a single term into several terms. Before calling the translation predicate with actual program terms, it is called with an input of `0` to give an opportunity of making initializations for the module, discarding the result (note that normally a 0 could not be there). `Predicate` must be exported by a module previously loaded with a `load_compilation_module/1` declaration. Normally included in package files.
- *The following properties hold at call time:*

  `Predicate` is a translation predicate spec (has arity 2 or 3). (`syntax_extensions:translation_predname/1`)

add_term_trans/1: DECLARATION

Usage: :- `add_term_trans(P).`

- *Description:* Starts a translation, defined by `Predicate`, of the terms and sub-terms read by the compiler in the rest of the current text. This translation is performed after all translations defined by `add_sentence_trans/1` are done. For each subsequent term read by the compiler, and recursively any subterm included, the translation predicate is called to possibly obtain a new term to replace the old one. Care must

be taken of not introducing an endless loop of translations. `Predicate` must be exported by a module previously loaded with a `load_compilation_module/1` declaration. Normally included in package files.

– *The following properties hold at call time:*

`P` is a translation predicate spec (has arity 2 or 3). (`syntax_extensions:translation_predname/1`)

add_goal_trans/1: DECLARATION

Usage: `:- add_goal_trans(Predicate).`

– *Description:* Declares a translation, defined by `Predicate`, of the goals present in the clauses of the current text. This translation is performed after all translations defined by `add_sentence_trans/1` and `add_term_trans/1` are done. For each clause read by the compiler, the translation predicate is called with each goal present in the clause to possibly obtain other goal to substitute the original one, and the translation is subsequently applied to the resulting goal. Care must be taken of not introducing an endless loop of translations. `Predicate` must be exported by a module previously loaded with a `load_compilation_module/1` declaration. Bear in mind that this type of translation noticeably slows down compilation. Normally included in package files.

– *The following properties hold at call time:*

`Predicate` is a translation predicate spec (has arity 2 or 3). (`syntax_extensions:translation_predname/1`)

add_clause_trans/1: DECLARATION

Usage: `:- add_clause_trans(Predicate).`

– *Description:* Declares a translation, defined by `Predicate`, of the clauses of the current text. The translation is performed before `add_goal_trans/1` translations but after `add_sentence_trans/1` and `add_term_trans/1` translations. The usefulness of this translation is that information of the interface of related modules is available when it is performed. For each clause read by the compiler, the translation predicate is called with the first argument instantiated to a structure `clause(Head,Body)`, and the predicate must return in the second argument a similar structure, without changing the functor in `Head` (or fail, in which case the clause is used as is). Before executing the translation predicate with actual clauses it is called with an input of `clause(0,0)`, discarding the result.

– *The following properties hold at call time:*

`Predicate` is a translation predicate spec (has arity 2 or 3). (`syntax_extensions:translation_predname/1`)

translation_predname/1: REGTYPE

A translation predicate is a predicate of arity 2 or 3 used to make compile-time translations. The compiler invokes a translation predicate instantiating its first argument with the item to be translated, and if the predicate is of arity 3 its third argument with the name of the module where the translation is done. If the call is successful, the second argument is used as if that item were in the place of the original, else the original item is used.

Usage: `translation_predname(P)`

– *Description:* `P` is a translation predicate spec (has arity 2 or 3).

27 Message printing primitives

Author(s): Daniel Cabeza.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

This module provides predicates for printing in a unified way informational messages, and also for printing some terms in a specific way.

27.1 Usage and interface (io_aux)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `message/2`, `message_lns/4`, `display_string/1`.

27.2 Documentation on exports (io_aux)

message/2: PREDICATE

`message(Type,Message)`

Output to standard error `Message`, which is of type `Type`. The `quiet` *prolog flag* (see Chapter 24 [Changing system behaviour and various flags], page 133) controls which messages are actually output, depending on its type. Also, for `error`, `warning` and `note` messages, a prefix is output which denotes the severity of the message. `Message` is an item or a list of items from this list:

`$$(String)`
: `String` is a string, which is output with `display_string/1`.

`''(Term)`
: `Term` is output quoted. If the module `write` is loaded, the term is output with `writeq/1`, else with `displayq/1`.

`~~(Term)`
: `Term` is output unquoted. If the module `write` is loaded, the term is output with `write/1`, else with `display/1`.

`[](Term)`
: `Term` is recursively output as a message, can be an item or a list of items from this list.

`Term`
: Any other term is output with `display/1`.

Usage 1: `message(Type,Message)`

- *The following properties should hold at call time:*
  `Type` is an atom. (`basic_props:atm/1`)
  `Type` is an element of `[error,warning,note,message,debug]`. (`basic_props:member/2`)

Usage 2: `message(Type,Message)`

- *The following properties should hold at call time:*
  `Type` is an atom. (`basic_props:atm/1`)
  `Type` is an element of `[error,warning,note,message,debug]`. (`basic_props:member/2`)

message_lns/4: PREDICATE

`message_lns(Type,L0,L1,Message)`

Output to standard error `Message`, which is of type `Type`, and occurs between lines `L0` and `L1`. This is the same as `message/2`, but printing the lines where the message occurs in a unified way (this is useful because automatic tools such as the emacs mode know how to parse them).

Usage 1: `message_lns(Type,L0,L1,Message)`

— *The following properties should hold at call time:*

`Type` is an atom. (`basic_props:atm/1`)

`Type` is an element of `[error,warning,note,message,debug]`. (`basic_props:member/2`)

Usage 2: `message_lns(Type,L0,L1,Message)`

— *The following properties should hold at call time:*

`Type` is an atom. (`basic_props:atm/1`)

`Type` is an element of `[error,warning,note,message,debug]`. (`basic_props:member/2`)

error/1: PREDICATE

Defined as

```
error(Message) :-
        message(error,Message).
```

.

warning/1: PREDICATE

Defined as

```
warning(Message) :-
        message(warning,Message).
```

.

note/1: PREDICATE

Defined as

```
note(Message) :-
        message(note,Message).
```

.

message/1: PREDICATE

Defined as

```
message(Message) :-
        message(message,Message).
```

.

debug/1: PREDICATE

Defined as

```
debug(Message) :-
        message(debug,Message).
```

.

inform_user/1: PREDICATE

`inform_user(Message)`

Similar to `message/1`, but `Message` is output with `display_list/1`. This predicate is obsolete, and may disappear in future versions.

display_string/1: PREDICATE

`display_string(String)`

Output `String` as the sequence of characters it represents.

Usage 1: `display_string(String)`

- *The following properties should hold at call time:*

  `String` is a string (a list of character codes). (`basic_props:string/1`)

Usage 2: `display_string(String)`

- *The following properties should hold at call time:*

  `String` is a string (a list of character codes). (`basic_props:string/1`)

display_list/1: PREDICATE

`display_list(List)`

Outputs `List`. If `List` is a list, do `display/1` on each of its elements, else do `display/1` on `List`.

display_term/1: PREDICATE

`display_term(Term)`

Output `Term` in a way that a `read/1` will be able to read it back, even if operators change.

27.3 Known bugs and planned improvements (`io_aux`)

- `message/2` assumes that a module with name 'write' is library(write).

28 Attributed variables

Author(s): Christian Holzbaur, Daniel Cabeza, Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#157 (2000/5/30, 13:4:47 CEST)

These predicates allow the manipulation of *attributed variables*. Attributes are special terms which are attached to a (free) variable, and are hidden from the normal Prolog computation. They can only be treated by using the predicates below.

28.1 Usage and interface (attributes)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `attach_attribute/2`, `get_attribute/2`, `update_attribute/2`, `detach_attribute/1`.
  - *Multifiles:*
    `verify_attribute/2`, `combine_attributes/2`.

28.2 Documentation on exports (attributes)

attach_attribute/2: PREDICATE

Usage 1: `attach_attribute(Var,Attr)`

- *Description:* Attach attribute `Attr` to `Var`.
- *The following properties should hold at call time:*
  `Var` is a free variable. (`term_typing:var/1`)
  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

Usage 2: `attach_attribute(Var,Attr)`

- *Description:* Attach attribute `Attr` to `Var`.
- *The following properties should hold at call time:*
  `Var` is a free variable. (`term_typing:var/1`)
  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

get_attribute/2: PREDICATE

Usage 1: `get_attribute(Var,Attr)`

- *Description:* Unify `Attr` with the attribute of `Var`, or fail if `Var` has no attribute.
- *The following properties should hold at call time:*
  `Var` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*
  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

Usage 2: `get_attribute(Var,Attr)`

- *Description:* Unify `Attr` with the attribute of `Var`, or fail if `Var` has no attribute.
- *The following properties should hold at call time:*

  `Var` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*

  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

update_attribute/2: PREDICATE

Usage 1: `update_attribute(Var,Attr)`

- *Description:* Change the attribute of attributed variable `Var` to `Attr`.
- *The following properties should hold at call time:*

  `Var` is a free variable. (`term_typing:var/1`)

  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

Usage 2: `update_attribute(Var,Attr)`

- *Description:* Change the attribute of attributed variable `Var` to `Attr`.
- *The following properties should hold at call time:*

  `Var` is a free variable. (`term_typing:var/1`)

  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

detach_attribute/1: PREDICATE

Usage 1: `detach_attribute(Var)`

- *Description:* Take out the attribute from the attributed variable `Var`.
- *The following properties should hold at call time:*

  `Var` is a free variable. (`term_typing:var/1`)

Usage 2: `detach_attribute(Var)`

- *Description:* Take out the attribute from the attributed variable `Var`.
- *The following properties should hold at call time:*

  `Var` is a free variable. (`term_typing:var/1`)

28.3 Documentation on multifiles (`attributes`)

verify_attribute/2: PREDICATE

The predicate is *multifile*.

Usage: `verify_attribute(Attr,Term)`

- *Description: A user defined predicate.* This predicate is called when an attributed variable with attribute `Attr` is about to be unified with the non-variable term `Term`. The user should define this predicate (as multifile) in the modules implementing special unification.
- *The following properties should hold at call time:*

  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

  `Term` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

combine_attributes/2: PREDICATE

The predicate is *multifile.*

Usage: `combine_attributes(Var1,Var2)`

- *Description: A user defined predicate.* This predicate is called when two attributed variables with attributes `Var1` and `Var2` are about to be unified. The user should define this predicate (as multifile) in the modules implementing special unification.
- *The following properties should hold at call time:*

  `Var1` is a free variable. (`term_typing:var/1`)

  `Var2` is a free variable. (`term_typing:var/1`)

28.4 Other information (attributes)

Note that `combine_attributes/2` and `verify_attribute/2` are not called with the attributed variables involved, but with the corresponding attributes instead. The reasons are:

- There are simple applications which only refer to the attributes.
- If the application wants to refer to the attributed variables themselves, they can be made part the attribute term. The implementation of `freeze/2` utilizes this technique. Note that this does not lead to cyclic structures, as the connection between an attributed variable and its attribute is invisible to the pure parts of the Prolog implementation.
- If attributed variables were passed as arguments, the user code would have to refer to the attributes through an extra call to `get_attribute/2`.
- As the/one attribute is the first argument to each of the two predicates, indexing applies. Note that attributed variables themselves look like variables to the indexing mechanism.

However, future improvements may change or extend the interface to attributed variables in order to provide a richer and more expressive interface.

For customized output of attributed variables, please refer to the documentation of the predicate `portray_attribute/2`.

29 Gathering some basic internal info

Author(s): Daniel Cabeza, Manuel Carro.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.3#13 (1999/7/2, 18:49:49 MEST)
This module provides predicates which return basic internal info.

29.1 Usage and interface (system_info)

- **Library usage:**
  These predicates are builtin in Ciao, so nothing special has to be done to use them.
- **Exports:**
  - *Predicates:*
    `get_arch/1`, `get_os/1`, `this_module/1`, `current_module/1`, `ciaolibdir/1`.

29.2 Documentation on exports (system_info)

get_arch/1: PREDICATE

This predicate will describe the computer architecture wich is currently executing the predicate.

Computer architectures are identified by a simple atom. This atom is implementation-defined, and may suffer any change from one Ciao Prolog version to another.

For example,Ciao Prolog running on an Intel-based machine will retrieve:

```
?- get_arch(I).

I = i86 ? ;

no
?-
```

Usage 1: `get_arch(?ArchDescriptor)`

- *Description:* Unifies `ArchDescriptor` with a simple atom which describes the computer architecture currently executing the predicate.
- *Calls should, and exit will be compatible with:*
  `?ArchDescriptor` is an atom. (`basic_props:atm/1`)

Usage 2: `get_arch(ArchDescriptor)`

- *Description:* Unifies `ArchDescriptor` with a simple atom which describes the computer architecture currently executing the predicate.
- *Calls should, and exit will be compatible with:*
  `ArchDescriptor` is an atom. (`basic_props:atm/1`)

get_os/1: PREDICATE

This predicate will describe the Operating System which is running on the machine currently executing the Prolog program.

Operating Systems are identified by a simple atom. This atom is implementation-defined, and may suffer any change from one Ciao Prolog version to another.

For example,Ciao Prolog running on Linux will retrieve:

```
?- get_os(I).

I = 'LINUX' ? ;

no
?-
```

Usage 1: `get_os(?OsDescriptor)`

- *Description:* Unifies `OsDescriptor` with a simple atom which describes the running Operating System when predicate was called.
- *Calls should, and exit will be compatible with:*

  `?OsDescriptor` is an atom. (`basic_props:atm/1`)

Usage 2: `get_os(OsDescriptor)`

- *Description:* Unifies `OsDescriptor` with a simple atom which describes the running Operating System when predicate was called.
- *Calls should, and exit will be compatible with:*

  `OsDescriptor` is an atom. (`basic_props:atm/1`)

this_module/1: PREDICATE

Meta-predicate with arguments: `this_module(addmodule)`.

Usage 1: `this_module(Module)`

- *Description:* `Module` is the internal module identifier for current module.
- *Call and exit should be compatible with:*

  `Module` is an internal module identifier (`system_info:internal_module_id/1`)

Usage 2: `this_module(Module)`

- *Description:* `Module` is the internal module identifier for current module.
- *Call and exit should be compatible with:*

  `Module` is an internal module identifier (`system_info:internal_module_id/1`)

current_module/1: PREDICATE

This predicate will successively unify its argument with all module names currently loaded. Module names will be simple atoms.

When called using a free variable as argument, it will retrieve on backtracking all modules currently loaded. This is usefull when called from the Ciao `toplevel`.

When called using a module name as argument it will check whether the given module is loaded or not. This is usefull when called from user programs.

Usage 1: `current_module(Module)`

- *Description:* Retrieves (on backtracking) all currently loaded modules into your application.

– *Call and exit should be compatible with:*

`Module` is an internal module identifier (`system_info:internal_module_id/1`)

Usage 2: `current_module(Module)`

– *Description:* Retrieves (on backtracking) all currently loaded modules into your application.

– *Call and exit should be compatible with:*

`Module` is an internal module identifier (`system_info:internal_module_id/1`)

ciaolibdir/1: PREDICATE

Usage 1: `ciaolibdir(CiaoPath)`

– *Description:* `CiaoPath` is the path to the root of the Ciao libraries. Inside this directory, there are the directories 'lib', 'library' and 'contrib', which contain library modules.

– *Call and exit should be compatible with:*

`CiaoPath` is an atom. (`basic_props:atm/1`)

Usage 2: `ciaolibdir(CiaoPath)`

– *Description:* `CiaoPath` is the path to the root of the Ciao libraries. Inside this directory, there are the directories 'lib', 'library' and 'contrib', which contain library modules.

– *Call and exit should be compatible with:*

`CiaoPath` is an atom. (`basic_props:atm/1`)

29.3 Documentation on internals (`system_info`)

internal_module_id/1: PROPERTY

For a user file it is a term user/1 with an argument different for each user file, for other modules is just the name of the module (as an atom).

Usage: `internal_module_id(M)`

– *Description:* `M` is an internal module identifier

PART III - ISO-Prolog library (iso)

This part documents the *iso* package which provides to Ciao programs (most of) the ISO-Prolog functionality , including the *ISO-Prolog builtins* not covered by the basic library. All these predicates are loaded by default in user files and in modules which use standard module declarations such as:

```
:- module(modulename,exports).
```

which are equivalent to:

```
:- module(modulename,exports,[iso]).
```

or

```
:- module(modulename,exports).
:- use_package([iso]).
```

If you do not want these ISO builtins loaded for a given file (in order to make the executable smaller) you can ask for this explicitly using:

```
:- module(modulename,exports,[]).
```

or

```
:- module(modulename,exports).
:- use_package([]).
```

See the description of the declarations for declaring modules and using other modules, and the documentation of the `iso` library for details.

30 ISO-Prolog package

This library package allows the use of the ISO-Prolog predicates in Ciao programs. It is included by default in modules starting with a `module/2` declaration or user files without a starting `use_package/1` declaration.

30.1 Usage and interface (`iso`)

- **Library usage:**

  ```
  :- use_package(iso).
  ```

  or

  ```
  :- module(...,...,[iso]).
  ```

- **Other modules used:**
  - *System library modules:*

    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`.

31 All solutions predicates

Author(s): First version by Richard A. O'Keefe and David H.D. Warren. Changes by Mats Carlsson, Daniel Cabeza, and Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#115 (2000/4/12, 12:17:22 CEST)

This module implements the standard solution aggregation predicates.

When there are many solutions to a problem, and when all those solutions are required to be collected together, this can be achieved by repeatedly backtracking and gradually building up a list of the solutions. The following built-in predicates are provided to automate this process.

31.1 Usage and interface (aggregates)

- **Library usage:**
  `:- use_module(library(aggregates)).`
- **Exports:**
  - *Predicates:*
    `setof/3`, `bagof/3`, `findall/3`, `findall/4`, `findnsols/4`, `findnsols/5`, `^/2`.
- **Other modules used:**
  - *System library modules:*
    `sort`, `lists`.

31.2 Documentation on exports (aggregates)

setof/3: PREDICATE

`setof(Template,Generator,Set)`

Finds the `Set` of instances of the `Template` satisfying `Generator`. The set is in ascending order (see Chapter 18 [Comparing terms], page 105 for a definition of this order) without duplicates, and is non-empty. If there are no solutions, `setof` fails. `setof` may succeed in more than one way, binding free variables in `Generator` to different values. This can be avoided by using existential quantifiers on the free variables in front of `Generator`, using `^/2`. For example, given the clauses:

```
father(bill, tom).
father(bill, ann).
father(bill, john).
father(harry, july).
father(harry, daniel).
```

The following query produces two alternative solutions via backtracking:

```
?- setof(X,father(F,X),Sons).

F = bill,
Sons = [ann,john,tom] ? ;

F = harry,
Sons = [daniel,july] ? ;
```

```
no
?-
```

Meta-predicate with arguments: `setof(?,goal,?)`.

bagof/3: PREDICATE

`bagof(Template,Generator,Bag)`

Finds all the instances of the `Template` produced by the `Generator`, and returns them in the `Bag` in the order in which they were found. If the `Generator` contains free variables which are not bound in the `Template`, it assumes that this is like any other Prolog question and that you want bindings for those variables. This can be avoided by using existential quantifiers on the free variables in front of the `Generator`, using `^/2`.

Meta-predicate with arguments: `bagof(?,goal,?)`.

findall/3: PREDICATE

`findall(Template,Generator,List)`

A special case of bagof, where all free variables in the `Generator` are taken to be existentially quantified. Faster than the other aggregation predicates.

Meta-predicate with arguments: `findall(?,goal,?)`.

findall/4: PREDICATE

Meta-predicate with arguments: `findall(?,goal,?,?)`.

Usage: `findall(Template,Generator,List,Tail)`

– *Description:* As `findall/3`, but returning in `Tail` the tail of `List`.

findnsols/4: PREDICATE

`findnsols(N,Template,Generator,List)`

As `findall/3`, but generating at most `N` solutions of `Generator`. Thus, the length of `List` will not be greater than `N`. If `N=<0`, returns directly an empty list. This predicate is especially useful if `Generator` may have an infinite number of solutions.

Meta-predicate with arguments: `findnsols(?,?,goal,?)`.

findnsols/5: PREDICATE

`findnsols(N,Template,Generator,List,Tail)`

As `findnsols/4`, but returning in `Tail` the tail of `List`.

Meta-predicate with arguments: `findnsols(?,?,goal,?,?)`.

^/2: PREDICATE

Usage: `X ^ P`

– *Description:* Existential quantification: `X` is existentially quantified in `P`. E.g., in `A^p(A,B)`, `A` is existentially quantified. Used only within aggregation predicates. In all other contexts, simply, execute the procedure call `P`.

32 Dynamic predicates

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#93 (2001/4/24, 19:2:53 CEST)

This module implements the assert/retract family of predicates to manipulate dynamic predicates.

The predicates defined in this module allow modification of the program as it is actually running. Clauses can be added to the program (*asserted*) or removed from the program (*retracted*). For these predicates, the argument which corresponds to the clause head must be instantiated to an atom or a compound term. The argument corresponding to the clause must be instantiated either to a term `Head :- Body` or, if the body part is empty, to `Head`. An empty body part is represented as `true`. Note that using this library is very detrimental to global analysis, and that for most uses the predicates listed in Chapter 25 [Fast/concurrent update of facts], page 139 suffice.

32.1 Usage and interface (`dynamic`)

- **Library usage:**

  `:- use_module(library(dynamic)).`
- **Exports:**
  - *Predicates:*

    `asserta/1`, `asserta/2`, `assertz/1`, `assertz/2`, `assert/1`, `assert/2`, `retract/1`, `retractall/1`, `abolish/1`, `clause/2`, `clause/3`, `current_predicate/1`, `current_predicate/2`, `dynamic/1`, `data/1`, `wellformed_body/3`.
  - *Multifiles:*

    `do_on_abolish/1`.
- **Other modules used:**
  - *System library modules:*

    `prolog_sys`.

32.2 Documentation on exports (`dynamic`)

asserta/1: PREDICATE

Meta-predicate with arguments: `asserta(clause)`.

Usage: `asserta(+Clause)` ⟨• ISO •⟩

- *Description:* The current instance of `Clause` is interpreted as a clause and is added to the current program. The predicate concerned must be dynamic. The new clause becomes the *first* clause for the predicate concerned. Any uninstantiated variables in `Clause` will be replaced by new private variables.

asserta/2: PREDICATE

Meta-predicate with arguments: `asserta(clause,?)`.

Usage: `asserta(+Clause,-Ref)`

- *Description:* Like `asserta/1`. `Ref` is a unique identifier of the asserted clause.

assertz/1: PREDICATE

Meta-predicate with arguments: `assertz(clause)`.

Usage: `assertz(+Clause)` ⟨• ISO •⟩

– *Description:* Like `asserta/1`, except that the new clause becomes the *last* clause for the predicate concerned.

assertz/2: PREDICATE

Meta-predicate with arguments: `assertz(clause,?)`.

Usage: `assertz(+Clause,-Ref)`

– *Description:* Like `assertz/1`. `Ref` is a unique identifier of the asserted clause.

assert/1: PREDICATE

Meta-predicate with arguments: `assert(clause)`.

Usage: `assert(+Clause)`

– *Description:* Identical to `assertz/1`. Included for compatibility.

assert/2: PREDICATE

Meta-predicate with arguments: `assert(clause,?)`.

Usage: `assert(+Clause,-Ref)`

– *Description:* Identical to `assertz/2`. Included for compatibility.

retract/1: PREDICATE

Meta-predicate with arguments: `retract(clause)`.

Usage: `retract(+Clause)` ⟨• ISO •⟩

– *Description:* The first clause in the program that matches `Clause` is erased. The predicate concerned must be dynamic.

The predicate `retract/1` may be used in a non-determinate fashion, i.e., it will successively retract clauses matching the argument through backtracking. If reactivated by backtracking, invocations of the predicate whose clauses are being retracted will proceed unaffected by the retracts. This is also true for invocations of `clause` for the same predicate. The space occupied by a retracted clause will be recovered when instances of the clause are no longer in use.

retractall/1: PREDICATE

Meta-predicate with arguments: `retractall(fact)`.

Usage: `retractall(+Head)`

– *Description:* Erase all clauses whose head matches `Head`, where `Head` must be instantiated to an atom or a compound term. The predicate concerned must be dynamic. The predicate definition is retained.

abolish/1: PREDICATE

Meta-predicate with arguments: `abolish(spec)`.

Usage: `abolish(+Spec)` ⟨• ISO •⟩

– *Description:* Erase all clauses of the predicate specified by the predicate spec `Spec`. The predicate definition itself is also erased (the predicate is deemed undefined after execution of the abolish). The predicates concerned must all be user defined.

clause/2: PREDICATE

Meta-predicate with arguments: `clause(fact,?)`.

Usage: `clause(+Head,?Body)` ⟨• ISO •⟩

– *Description:* The clause '`Head :- Body`' exists in the current program. The predicate concerned must be dynamic.

clause/3: PREDICATE

`clause(Head,Body,Ref)`

Like `clause(Head,Body)`, plus the clause is uniquely identified by `Ref`.

Meta-predicate with arguments: `clause(fact,?,?)`.

Usage 1: `clause(+Head,?Body,?Ref)`

– *Description:* `Head` must be instantiated to an atom or a compound term.

Usage 2: `clause(?Head,?Body,+Ref)`

– *Description:* `Ref` must be instantiated to a valid identifier.

current_predicate/1: PREDICATE

Usage: `current_predicate(?Spec)` ⟨• ISO •⟩

– *Description:* A predicate in the current module is named `Spec`.

current_predicate/2: PREDICATE

Usage: `current_predicate(?Spec,?Module)`

– *Description:* A predicate in `Module` is named `Spec`. `Module` never is an engine module.

dynamic/1: PREDICATE

`dynamic F/A`

The predicate named `F` with arity `A` is made dynamic in the current module at runtime (useful for predicate names generated on-the-fly). If the predicate functor name `F` is uninstatiated, a new, unique, predicate name is generated at runtime.

data/1: PREDICATE

`data F/A`

The predicate named `F` with arity `A` is made data in the current module at runtime (useful for predicate names generated on-the-fly). If the predicate functor name `F` is uninstatiated, a new, unique, predicate name is generated at runtime.

wellformed_body/3: PREDICATE

`wellformed_body(BodyIn,Env,BodyOut)`

`BodyIn` is a well-formed clause body. `BodyOut` is its counterpart with no single-variable meta-goals (i.e., with `call(X)` for `X`). `Env` denotes if global cuts are admissible in `BodyIn` (`+` if they are, `-` if they are not).

32.3 Documentation on multifiles (`dynamic`)

do_on_abolish/1: PREDICATE

`do_on_abolish(Head)`

A hook predicate which will be called when the definition of the predicate of `Head` is abolished.

The predicate is *multifile*.

33 Term input

Author(s): First versions from SICStus 0.6 code; additional changes and documentation by Daniel Cabeza and Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#196 (2002/4/17, 20:0:32 CEST)

33.1 Usage and interface (read)

- **Library usage:**
  `:- use_module(library(read)).`
- **Exports:**
  - *Predicates:*
    `read/1`, `read/2`, `read_term/2`, `read_term/3`, `read_top_level/3`, `second_prompt/2`.
  - *Multifiles:*
    `define_flag/3`.
- **Other modules used:**
  - *System library modules:*
    `tokenize`, `operators`, `lists`.

33.2 Documentation on exports (read)

read/1: PREDICATE

`read(Term)`

Like `read(Stream,Term)` with `Stream` associated to the current input stream.

read/2: PREDICATE

Usage: `read(+Stream,?Term)` ⟨• ISO •⟩

- *Description:* The next term, delimited by a full-stop (i.e., a . followed by either a space or a control character), is read from `Stream` and is unified with `Term`. The syntax of the term must agree with current operator declarations. If the end of `Stream` has been reached, `Term` is unified with the term `end_of_file`. Further calls to `read/2` for the same stream will then cause an error, unless the stream is connected to the terminal (in which case a prompt is opened on the terminal).
- *The following properties should hold upon exit:*
  `+Stream` is an open stream. (`streams_basic:stream/1`)
  `?Term` is any term. (`basic_props:term/1`)

read_term/2: PREDICATE

Usage: `read_term(?Term,+Options)` ⟨• ISO •⟩

- *Description:* Like `read_term/3`, but reading from the current input

– *The following properties should hold upon exit:*

`?Term` is any term. (`basic_props:term/1`)

`+Options` is a list of `read_options`. (`basic_props:list/2`)

read_term/3: PREDICATE

Usage: `read_term(+Stream,?Term,+Options)` ⟨• ISO •⟩

– *Description:* Reads a `Term` from `Stream` with the ISO-Prolog `Options`. These options can control the behavior of read term (see `read_option/1`).

– *The following properties should hold upon exit:*

`+Stream` is an open stream. (`streams_basic:stream/1`)

`?Term` is any term. (`basic_props:term/1`)

`+Options` is a list of `read_options`. (`basic_props:list/2`)

read_top_level/3: PREDICATE

No further documentation available for this predicate.

second_prompt/2: PREDICATE

Usage: `second_prompt(?Old,?New)`

– *Description:* Changes the prompt (the *second prompt*, as oposed to the first one, used by the toplevel) used by `read/2` and friends to `New`, and returns the current one in `Old`.

– *The following properties should hold upon exit:*

`?Old` is currently instantiated to an atom. (`term_typing:atom/1`)

`?New` is currently instantiated to an atom. (`term_typing:atom/1`)

33.3 Documentation on multifiles (`read`)

define_flag/3: PREDICATE

Defines flags as follows:

```
define_flag(read_hiord,[on,off],off).
```

(See Chapter 24 [Changing system behaviour and various flags], page 133).

If flag is `on` (it is `off` by default), a variable followed by a parenthesized lists of arguments is read as a `call/N` term, except if the variable is anonymous, in which case it is read as an anonymous predicate abstraction head. For example, `P(X)` is read as `call(P,X)` and `_(X,Y)` as `''(X,Y)`.

The predicate is *multifile*.

33.4 Documentation on internals (`read`)

read_option/1: REGTYPE

Usage: `read_option(Option)`

- *Description:* `Option` is an allowed `read_term/[2,3]` option. These options are:

```
read_option(variables(_V)).
read_option(variable_names(_N)).
read_option(singletons(_S)).
read_option(lines(_StartLine,_EndLine)).
read_option(dictionary(_Dict)).
```

  They can be used to return the singleton variables in the term, a list of variables, etc.

- *The following properties should hold upon exit:*

  `Option` is currently instantiated to an atom. (`term_typing:atom/1`)

34 Term output

Author(s): Adapted from shared code written by Richard A. O'Keefe. Changes by Mats Carlsson, Daniel Cabeza, Manuel Hermenegildo, and Manuel Carro..

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#197 (2002/4/17, 20:2:28 CEST)

This library provides different predicates for term output, additional to the kernel predicates `display/1- display/2` and `displayq/1-displayq/2`. All the predicates defined in ISO-Prolog are included, plus other traditionally provided by Prolog Implementations. Output predicates are provided in two versions: one that uses the current output stream and other in which the stream is specified explicitly, as an additional first argument.

34.1 Usage and interface (`write`)

- **Library usage:**

  `:- use_module(library(write)).`
- **Exports:**
  - *Predicates:*

    `write_term/3`, `write_term/2`, `write/2`, `write/1`, `writeq/2`, `writeq/1`, `write_canonical/2`, `write_canonical/1`, `print/2`, `print/1`, `write_list1/1`, `portray_clause/2`, `portray_clause/1`, `numbervars/3`, `prettyvars/1`, `printable_char/1`.
  - *Properties:*

    `write_option/1`.
  - *Multifiles:*

    `define_flag/3`, `portray_attribute/2`, `portray/1`.
- **Other modules used:**
  - *System library modules:*

    `operators`, `sort`.

34.2 Documentation on exports (`write`)

write_term/3: PREDICATE

Usage: `write_term(@Stream,?Term,+OptList)` ⟨• ISO •⟩

- *Description:* Outputs the term `Term` to the stream `Stream`, with the list of write-options `OptList`. See `write_option/1` type for default options.
- *The following properties should hold upon exit:*

  `@Stream` is an open stream. (`streams_basic:stream/1`)

  `?Term` is any term. (`basic_props:term/1`)

  `+OptList` is a list of `write_options`. (`basic_props:list/2`)

write_term/2: PREDICATE

Usage: `write_term(?Term,+OptList)` ⟨• ISO •⟩

- *Description:* Behaves like `current_output(S), write_term(S,Term,OptList).`

– *The following properties should hold upon exit:*

`?Term` is any term. (`basic_props:term/1`)

`+OptList` is a list of `write_options`. (`basic_props:list/2`)

write_option/1: PROPERTY

`Opt` is a valid write option which affects the predicate `write_term/3` and similar ones. Possible write_options are:

- **quoted(*bool*):** If *bool* is `true`, atoms and functors that can't be read back by `read_term/3` are quoted, if it is `false`, each atom and functor is written as its name. Default value is `false`.
- **ignore_ops(*flag*):** If *flag* is `true`, each compound term is output in functional notation, if it is `ops`, curly bracketed notation and list notation is enabled when outputing compound terms, if it is `false`, also operator notation is enabled when outputing compound terms. Default value is `false`.
- **numbervars(*bool*):** If *bool* is `true`, a term of the form `'$VAR'(N)` where `N` is an integer, is output as a variable name consisting of a capital letter possibly followed by an integer, a term of the form `'$VAR'(Atom)` where `Atom` is an atom, as this atom (without quotes), and a term of the form `'$VAR'(String)` where `String` is a character string, as the atom corresponding to this character string. See predicates `numbervars/3` and `prettyvars/1`. If *bool* is `false` this cases are not treated in any special way. Default value is `false`.
- **portrayed(*bool*):** If *bool* is `true`, then call multifile predicates `portray/1` and `portray_attribute/1`, to provide the user handlers for pretty printing some terms. `portray_attribute/1` is called whenever an attributed variable is to be printed, `portray/1` is called whenever a non-variable term is to be printed. If either call succeeds, then it is assumed that the term has been output, else it is printed as usual. If *bool* is `false`, these predicates are not called. Default value is `false`. This option is set by the toplevel when writting the final values of variables, and by the debugging package when writting the goals in the tracing messages. Thus you can vary the forms of these messages if you wish.
- **max_depth(*depth*):** *depth* is a positive integer or cero. If it is positive, it denotes the depth limit on printing compound terms. If it is cero, there is no limit. Default value is `0` (no limit).
- **priority(*prio*):** *prio* is an integer between 1 and 1200. If the term to be printed has higher priority than *prio*, it will be printed parenthesized. Default value is 1200 (no term parenthesized).

.

Usage: `write_option(Opt)`

– *Description:* `Opt` is a valid write option.

write/2: PREDICATE

Usage: `write(@Stream,?Term)` ⟨• ISO •⟩

– *Description:* Behaves like `write_term(Stream, Term, [numbervars(true)])`.

– *The following properties should hold upon exit:*

`@Stream` is an open stream. (`streams_basic:stream/1`)

`?Term` is any term. (`basic_props:term/1`)

write/1: PREDICATE

Usage: `write(?Term)` ⟨• ISO •⟩

- *Description:* Behaves like `current_output(S), write(S,Term).`
- *The following properties should hold upon exit:*

  `?Term` is any term. (`basic_props:term/1`)

writeq/2: PREDICATE

Usage: `writeq(@Stream,?Term)` ⟨• ISO •⟩

- *Description:* Behaves like `write_term(Stream, Term, [quoted(true), numbervars(true)]).`
- *The following properties should hold upon exit:*

  `@Stream` is an open stream. (`streams_basic:stream/1`)

  `?Term` is any term. (`basic_props:term/1`)

writeq/1: PREDICATE

Usage: `writeq(?Term)` ⟨• ISO •⟩

- *Description:* Behaves like `current_output(S), writeq(S,Term).`
- *The following properties should hold upon exit:*

  `?Term` is any term. (`basic_props:term/1`)

write_canonical/2: PREDICATE

Usage: `write_canonical(@Stream,?Term)` ⟨• ISO •⟩

- *Description:* Behaves like `write_term(Stream, Term, [quoted(true), ignore_ops(true)]).` The output of this predicate can always be parsed by `read_term/2` even if the term contains special characters or if operator declarations have changed.
- *The following properties should hold upon exit:*

  `@Stream` is an open stream. (`streams_basic:stream/1`)

  `?Term` is any term. (`basic_props:term/1`)

write_canonical/1: PREDICATE

Usage: `write_canonical(?Term)` ⟨• ISO •⟩

- *Description:* Behaves like `current_output(S), write_canonical(S,Term).`
- *The following properties should hold upon exit:*

  `?Term` is any term. (`basic_props:term/1`)

print/2: PREDICATE

Usage: `print(@Stream,?Term)`

- *Description:* Behaves like `write_term(Stream, Term, [numbervars(true), portrayed(true)]).`
- *The following properties should hold upon exit:*

  `@Stream` is an open stream. (`streams_basic:stream/1`)

  `?Term` is any term. (`basic_props:term/1`)

print/1: PREDICATE

Usage: `print(?Term)`

- *Description:* Behaves like `current_output(S), print(S,Term).`
- *The following properties should hold upon exit:*

  `?Term` is any term. (`basic_props:term/1`)

write_list1/1: PREDICATE

Usage:

- *Description:* Writes a list to current output one element in each line.
- *Call and exit should be compatible with:*

  `Arg1` is a list. (`basic_props:list/1`)

portray_clause/2: PREDICATE

Usage: `portray_clause(@Stream,?Clause)`

- *Description:* Outputs the clause `Clause` onto `Stream`, pretty printing its variables and using indentation, including a period at the end. This predicate is used by `listing/0`.
- *The following properties should hold upon exit:*

  `@Stream` is an open stream. (`streams_basic:stream/1`)

  `?Clause` is any term. (`basic_props:term/1`)

portray_clause/1: PREDICATE

Usage: `portray_clause(?Clause)`

- *Description:* Behaves like `current_output(S), portray_clause(S,Term).`
- *The following properties should hold upon exit:*

  `?Clause` is any term. (`basic_props:term/1`)

numbervars/3: PREDICATE

Usage: `numbervars(?Term,+N,?M)`

- *Description:* Unifies each of the variables in term `Term` with a term of the form `'$VAR'(I)` where `I` is an integer from `N` onwards. `M` is unified with the last integer used plus 1. If the resulting term is output with a write option `numbervars(true)`, in the place of the variables in the original term will be printed a variable name consisting of a capital letter possibly followed by an integer. When `N` is 0 you will get the variable names A, B, ..., Z, A1, B1, etc.
- *The following properties should hold upon exit:*

  `?Term` is any term. (`basic_props:term/1`)

  `+N` is currently instantiated to an integer. (`term_typing:integer/1`)

  `?M` is currently instantiated to an integer. (`term_typing:integer/1`)

prettyvars/1: PREDICATE

Usage: `prettyvars(?Term)`

- *Description:* Similar to `numbervars(Term,0,_)`, except that singleton variables in `Term` are unified with `'$VAR'('_')`, so that when the resulting term is output with a write option `numbervars(true)`, in the place of singleton variables _ is written. This predicate is used by `portray_clause/2`.
- *The following properties should hold upon exit:*

  `?Term` is any term. (`basic_props:term/1`)

printable_char/1: PREDICATE

Usage: `printable_char(+Char)`

- *Description:* `Char` is the code of a character which can be printed.
- *The following properties should hold upon exit:*

  `+Char` is currently instantiated to a number. (`term_typing:number/1`)

34.3 Documentation on multifiles (`write`)

define_flag/3: PREDICATE

Defines flags as follows:

```
define_flag(write_strings,[on,off],off).
```

(See Chapter 24 [Changing system behaviour and various flags], page 133).

If flag is `on`, lists which may be written as strings are.

The predicate is *multifile*.

portray_attribute/2: PREDICATE

The predicate is *multifile*.

Usage: `portray_attribute(Attr,Var)`

- *Description: A user defined predicate.* When an attributed variable `Var` is about to be printed, this predicate receives the variable and its attribute `Attr`. The predicate should either print something based on `Attr` or `Var`, or do nothing and fail. In the latter case, the default printer (`write/1`) will print the attributed variable like an unbound variable, e.g. `_673`.
- *The following properties should hold at call time:*

  `Attr` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

  `Var` is a free variable. (`term_typing:var/1`)

portray/1: PREDICATE

The predicate is *multifile*.

Usage: `portray(?Term)`

- *Description: A user defined predicate.* This should either print the `Term` and succeed, or do nothing and fail. In the latter case, the default printer (`write/1`) will print the `Term`.

35 Defining operators

Author(s): Adapted from SICStus 0.6 code; modifications and documentation by Daniel Cabeza and Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#198 (2002/4/17, 20:13:7 CEST)

Operators allow writting terms in a more clear way than the standard functional notation. Standard operators in Ciao are defined by this predicate (but note that the compiler itself defines more operators at compile time):

```
standard_ops :-
        op(1200,xfx,[:-]),
        op(1200,fx,[:-,?-]),
        op(1100,xfy,[;]),
        op(1050,xfy,[->]),
        op(1000,xfy,[',']),
        op(900,fy,[\+]),
        op(700,xfx,[=,\=,==,\==,@<,@>,@=<,@>=,=..,is,=:=,=\=,<,=<,>,>=]),
        op(550,xfx,[:]),
        op(500,yfx,[+,-,/\,\/,#]),
        op(500,fy,[++,--]),
        op(400,yfx,[*,/,//,rem,mod,<<,>>]),
        op(200,fy,[+,-,\]),
        op(200,xfx,[**]),
        op(200,xfy,[^]),
        op(25,fy,[^]).
```

35.1 Usage and interface (operators)

- **Library usage:**
  `:- use_module(library(operators)).`
- **Exports:**
  - *Predicates:*
    `op/3`, `current_op/3`, `current_prefixop/3`, `current_infixop/4`, `current_postfixop/3`.

35.2 Documentation on exports (operators)

op/3: PREDICATE

`op(Precedence,Type,Name)`

Declares the atom `Name` to be an operator of the stated `Type` and `Precedence` (0 =< `Precedence` =< 1200). `Name` may also be a list of atoms in which case all of them are declared to be operators. If `Precedence` is 0 then the operator properties of `Name` (if any) are cancelled. Note that, unlike in ISO-Prolog, it is allowed to define two operators with the same name, one infix and the other postfix.

current_op/3: PREDICATE

`current_op(Precedence,Type,Op)`

The atom `Op` is currently an operator of type `Type` and precedence `Precedence`. Neither `Op` nor the other arguments need be instantiated at the time of the call; i.e., this predicate can be used to generate as well as to test.

current_prefixop/3: PREDICATE

`current_prefixop(Op,Less,Precedence)`

Similar to `current_op/3`, but it concerns only the prefix operators. It returns **only one solution**. Not a predicate for general use.

current_infixop/4: PREDICATE

`current_infixop(Op,LeftLess,Prec,RightLess)`

Similar to `current_op/3`, but it concerns only infix operators. It returns **only one solution**. Not a predicate for general use.

current_postfixop/3: PREDICATE

`current_postfixop(Op,Less,Precedence)`

Similar to `current_op/3`, but it concerns only the postfix operators. It returns **only one solution**. Not a predicate for general use.

36 iso_byte_char (library)

36.1 Usage and interface (iso_byte_char)

- **Library usage:**
  `:- use_module(library(iso_byte_char)).`
- **Exports:**
  - *Predicates:*
    `char_code/2`, `atom_chars/2`, `number_chars/2`, `get_byte/1`, `get_byte/2`, `peek_byte/1`, `peek_byte/2`, `put_byte/1`, `put_byte/2`, `get_char/1`, `get_char/2`, `peek_char/1`, `peek_char/2`, `put_char/1`, `put_char/2`.

36.2 Documentation on exports (iso_byte_char)

char_code/2: PREDICATE
No further documentation available for this predicate.

atom_chars/2: PREDICATE
No further documentation available for this predicate.

number_chars/2: PREDICATE
No further documentation available for this predicate.

get_byte/1: PREDICATE
No further documentation available for this predicate.

get_byte/2: PREDICATE
No further documentation available for this predicate.

peek_byte/1: PREDICATE
No further documentation available for this predicate.

peek_byte/2: PREDICATE
No further documentation available for this predicate.

put_byte/1: PREDICATE

No further documentation available for this predicate.

put_byte/2: PREDICATE

No further documentation available for this predicate.

get_char/1: PREDICATE

No further documentation available for this predicate.

get_char/2: PREDICATE

No further documentation available for this predicate.

peek_char/1: PREDICATE

No further documentation available for this predicate.

peek_char/2: PREDICATE

No further documentation available for this predicate.

put_char/1: PREDICATE

No further documentation available for this predicate.

put_char/2: PREDICATE

No further documentation available for this predicate.

37 iso_misc (library)

Version: 0.4#5 (1998/2/24)

37.1 Usage and interface (iso_misc)

- **Library usage:**
  `:- use_module(library(iso_misc)).`
- **Exports:**
  - *Predicates:*
    `\=/2`, `once/1`, `compound/1`, `sub_atom/5`, `unify_with_occurs_check/2`.
- **Other modules used:**
  - *System library modules:*
    `between`.

37.2 Documentation on exports (iso_misc)

\=/2: PREDICATE

No further documentation available for this predicate.

once/1: PREDICATE

No further documentation available for this predicate.

Meta-predicate with arguments: `once(goal)`.

compound/1: PREDICATE

No further documentation available for this predicate.

sub_atom/5: PREDICATE

No further documentation available for this predicate.

unify_with_occurs_check/2: PREDICATE

No further documentation available for this predicate.

38 iso_incomplete (library)

38.1 Usage and interface (iso_incomplete)

- **Library usage:**
  `:- use_module(library(iso_incomplete)).`
- **Exports:**
  - *Predicates:*
    `open/4`, `close/2`, `stream_property/2`.

38.2 Documentation on exports (iso_incomplete)

open/4: PREDICATE

No further documentation available for this predicate.

close/2: PREDICATE

No further documentation available for this predicate.

stream_property/2: PREDICATE

No further documentation available for this predicate.

PART IV - Classic Prolog library (classic)

This part documents some Ciao libraries which provide additional predicates and functionalities that, despite not being in the ISO standard, are present in many popular Prolog systems. This includes definite clause grammars (DCGs), "Quintus-style" internal database, list processing predicates, dictionaries, string processing, DEC-10 Prolog-style input/output, formatted output, dynamic loading of modules, activation of operators at run-time, etc.

39 Classic Prolog package

This library package allows the use of certain Prolog features which have become sort of 'classical' from many Prolog implementations. These include definite clause grammars and some classical predicates like `append/3`. The libraries listed below define these predicates, and the following chapters describe them.

39.1 Usage and interface (`classic`)

- **Library usage:**
  `:- use_package(classic).`
  or
  `:- module(...,...,[classic]).`
- **New operators defined:**
  `-->/2` [1200,xfx].
- **Other modules used:**
  - *System library modules:*
    `operators`, `old_database`, `lists`, `sort`, `dict`, `strings`, `dec10_io`, `format`, `ttyout`, `compiler/compiler`.

40 Definite clause grammars

This library package allows the use of DCGs (Definite Clause Grammars) [Col78,PW80] in a Ciao module/program.

Definite clause grammars are an extension of the well-known context-free grammars. Prolog's grammar rules provide a convenient notation for expressing definite clause grammars. A DCG rule in Prolog takes the general form

```
head --> body.
```

meaning "a possible form for `head` is `body`". Both `body` and `head` are sequences of one or more items linked by the standard Prolog conjunction operator `","`.

Definite clause grammars extend context-free grammars in the following ways:

1. A non-terminal symbol may be any Prolog term (other than a variable or number).
2. A terminal symbol may be any Prolog term. To distinguish terminals from non-terminals, a sequence of one or more terminal symbols is written within a grammar rule as a Prolog list. An empty sequence is written as the empty list `[]`. If the terminal symbols are ASCII character codes, such lists can be written (as elsewhere) as strings. An empty sequence is written as the empty list, `[]` or `""`.
3. Extra conditions, in the form of Prolog procedure calls, may be included in the right-hand side of a grammar rule. Such procedure calls are written enclosed in `{}` brackets.
4. The left-hand side of a grammar rule consists of a non-terminal, optionally followed by a sequence of terminals (again written as a Prolog list).
5. Alternatives may be stated explicitly in the right-hand side of a grammar rule, using the disjunction operator `;` or `|` as in Prolog.
6. The cut symbol may be included in the right-hand side of a grammar rule, as in a Prolog clause. The cut symbol does not need to be enclosed in `{}` brackets.

As an example, here is a simple grammar which parses an arithmetic expression (made up of digits and operators) and computes its value.

```
expr(Z) --> term(X), "+", expr(Y), {Z is X + Y}.
expr(Z) --> term(X), "-", expr(Y), {Z is X - Y}.
expr(X) --> term(X).

term(Z) --> number(X), "*", term(Y), {Z is X * Y}.
term(Z) --> number(X), "/", term(Y), {Z is X / Y}.
term(Z) --> number(Z).

number(C) --> "+", number(C).
number(C) --> "-", number(X), {C is -X}.
number(X) --> [C], {0'0=<C, C=<0'9, X is C - 0'0}.
```

In the last rule, `C` is the ASCII code of some digit.

The query

```
| ?- expr(Z, "-2+3*5+1", []).
```

will compute `Z`=14. The two extra arguments are explained below.

Now, in fact, grammar rules are merely a convenient "syntactic sugar" for ordinary Prolog clauses. Each grammar rule takes an input string, analyses some initial portion, and produces the remaining portion (possibly enlarged) as output for further analysis. The arguments required for the input and output strings are not written explicitly in a grammar rule, but the syntax implicitly defines them. We now show how to translate grammar rules into ordinary clauses by making explicit the extra arguments.

A rule such as

```
p(X) --> q(X).
```

translates into

```
p(X, S0, S) :- q(X, S0, S).
```

If there is more than one non-terminal on the right-hand side, as in

```
p(X, Y) -->
        q(X),
        r(X, Y),
        s(Y).
```

then corresponding input and output arguments are identified, as in

```
p(X, Y, S0, S) :-
        q(X, S0, S1),
        r(X, Y, S1, S2),
        r(Y, S2, S).
```

Terminals are translated using the built-in predicate `'C'/3` (this predicate is not normally useful in itself; it has been given the name `'C'` simply to avoid using up a more useful name). Then, for instance

```
p(X) --> [go,to], q(X), [stop].
```

is translated by

```
p(X, S0, S) :-
        'C'(S0, go, S1),
        'C'(S1, to, S2),
        q(X, S2, S3),
        'C'(S3, stop, S).
```

Extra conditions expressed as explicit procedure calls naturally translate as themselves, e.g.

```
p(X) --> [X], {integer(X), X>0}, q(X).
```

translates to

```
p(X, S0, S) :-
        'C'(S0, X, S1),
        integer(X),
        X>0,
        q(X, S1, S).
```

Similarly, a cut is translated literally.

Terminals on the left-hand side of a rule translate into an explicit list in the output argument of the main non-terminal, e.g.

```
is(N), [not] --> [aint].
```

becomes

```
is(N, S0, [not|S]) :- 'C'(S0, aint, S).
```

Disjunction has a fairly obvious translation, e.g.

```
args(X, Y) -->
        (   dir(X), [to], indir(Y)
        ;   indir(Y), dir(X)
        ).
```

translates to

```
args(X, Y, S0, S) :-
        (   dir(X, S0, S1),
            'C'(S1, to, S2),
            indir(Y, S2, S)
```

```
;   indir(Y, S0, S1),
    dir(X, S1, S)
).
```

40.1 Usage and interface (dcg)

- **Library usage:**
  `:- use_package(dcg).`
  or
  `:- module(...,...,[dcg]).`

41 Definite clause grammars (expansion)

Version: 0.4#5 (1998/2/24)

41.1 Usage and interface (dcg_expansion)

- **Library usage:**
  `:- use_module(library(dcg_expansion)).`
- **Exports:**
  - *Predicates:*
    `phrase/2`, `phrase/3`, `dcg_translation/2`.
- **Other modules used:**
  - *System library modules:*
    `terms`, `assertions/doc_props`.

41.2 Documentation on exports (dcg_expansion)

phrase/2: PREDICATE

`phrase(Phrase,List)`

Like `phrase(Phrase,List,[])`.

Meta-predicate with arguments: `phrase(goal,?)`.

phrase/3: PREDICATE

Meta-predicate with arguments: `phrase(goal,?,?)`.

Usage: `phrase(+Phrase,?List,?Remainder)`

- *Description:* The list `List` is a phrase of type `Phrase` (according to the current grammar rules), where `Phrase` is either a non-terminal or more generally a grammar rule body. `Remainder` is what remains of the list after a phrase has been found.
- *The following properties should hold globally:*
  Documentation is still incomplete: `phrase(+Phrase,?List,?Remainder)` may not conform the functionality documented. (`doc_props:doc_incomplete/1`)

dcg_translation/2: PREDICATE

Performs the code expansion of source clauses that use DCGs.

42 List processing

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.5#41 (2000/2/4, 13:34:24 CET)
This module provides a set of predicates for list processing.

42.1 Usage and interface (`lists`)

- **Library usage:**
  `:- use_module(library(lists)).`
- **Exports:**
  - *Predicates:*
    `nonsingle/1`, `append/3`, `reverse/2`, `reverse/3`, `delete/3`, `select/3`, `length/2`, `nth/3`, `add_after/4`, `add_before/4`, `dlist/3`, `list_concat/2`, `list_insert/2`, `insert_last/3`, `contains_ro/2`, `contains1/2`, `nocontainsx/2`, `last/2`, `list_lookup/3`, `list_lookup/4`, `intset_insert/3`, `intset_delete/3`, `intset_in/2`, `intset_sequence/3`, `intersection/3`, `union/3`, `difference/3`, `equal_lists/2`, `list_to_list_of_lists/2`, `powerset/2`.
  - *Properties:*
    `list1/2`, `sublist/2`, `subordlist/2`.

42.2 Documentation on exports (`lists`)

nonsingle/1: PREDICATE
Usage: `nonsingle(X)`
- *Description:* `X` is not a singleton.

append/3: PREDICATE
Usage: `append(Xs,Ys,Zs)`
- *Description:* `Zs` is `Ys` appended to `Xs`.

reverse/2: PREDICATE
Usage: `reverse(Xs,Ys)`
- *Description:* Reverses the order of elements in `Xs`.
- *The following properties should hold at call time:*
  `Xs` is a list. (`basic_props:list/1`)
  `Ys` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*
  `Xs` is a list. (`basic_props:list/1`)
  `Ys` is a list. (`basic_props:list/1`)

reverse/3: PREDICATE

No further documentation available for this predicate.

delete/3: PREDICATE

Usage: `delete(L1,E,L2)`

- *Description:* `L2` is `L1` without the ocurrences of `E`.

select/3: PREDICATE

Usage: `select(X,Xs,Ys)`

- *Description:* `Xs` and `Ys` have the same elements except for one occurrence of `X`.

length/2: PREDICATE

Usage 1: `length(L,N)`

- *Description:* Computes the length of `L`.
- *The following properties should hold at call time:*

  `L` is a list. (`basic_props:list/1`)

  `N` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*

  `L` is a list. (`basic_props:list/1`)

  `N` is currently instantiated to an integer. (`term_typing:integer/1`)

Usage 2: `length(L,N)`

- *Description:* Outputs `L` of length `N`.
- *The following properties should hold at call time:*

  `L` is a free variable. (`term_typing:var/1`)

  `N` is currently instantiated to an integer. (`term_typing:integer/1`)
- *The following properties should hold upon exit:*

  `L` is a list. (`basic_props:list/1`)

  `N` is currently instantiated to an integer. (`term_typing:integer/1`)

Usage 3: `length(L,N)`

- *Description:* Checks that `L` is of length `N`.
- *The following properties should hold at call time:*

  `L` is a list. (`basic_props:list/1`)

  `N` is currently instantiated to an integer. (`term_typing:integer/1`)
- *The following properties should hold upon exit:*

  `L` is a list. (`basic_props:list/1`)

  `N` is currently instantiated to an integer. (`term_typing:integer/1`)

nth/3: PREDICATE

`nth(N,List,Elem)`

`N` is the position in `List` of `Elem`. `N` counts from one.

Usage 1: `nth(+int,?list,?term)`

– *Description:* Unifies `Elem` and the `N`th element of `List`.

Usage 2: `nth(-int,?list,?term)`

– *Description:* Finds the positions where `Elem` is in `List`. Positions are found in ascending order.

add_after/4: PREDICATE

Usage: `add_after(+L0,+E0,+E,-L)`

– *Description:* Adds element `E` after element `E0` (or at end) to list `L0` returning in `L` the new list (uses term comparison).

add_before/4: PREDICATE

No further documentation available for this predicate.

list1/2: PROPERTY

Meta-predicate with arguments: `list1(?,pred(1))`.

Usage: `list1(X,Y)`

– *Description:* `X` is a list of `Y`s of at least one element.

dlist/3: PREDICATE

Usage: `dlist(List,DList,Tail)`

– *Description:* `List` is the result of removing `Tail` from the end of `DList` (makes a difference list from a list).

list_concat/2: PREDICATE

Usage: `list_concat(LL,L)`

– *Description:* `L` is the concatenation of all the lists in `LL`.

– *Call and exit should be compatible with:*

`LL` is a list of `lists`. (`basic_props:list/2`)

`L` is a list. (`basic_props:list/1`)

list_insert/2: PREDICATE

Usage: `list_insert(-List,+Term)`

– *Description:* Adds `Term` to the end of `List` if there is no element in `List` identical to `Term`.

insert_last/3: PREDICATE

Usage: `insert_last(+L0,+E,-L)`

– *Description:* Adds element `E` at end of list `L0` returning `L`.

contains_ro/2: PREDICATE

Usage:

– *Description:* Impure membership (does not instantiate a variable in its first argument.

contains1/2: PREDICATE

No further documentation available for this predicate.

nocontainsx/2: PREDICATE

Usage: `nocontainsx(L,X)`

– *Description:* `X` is not identical to any element of `L`.

last/2: PREDICATE

Usage: `last(L,X)`

– *Description:* X is the last element of L.

list_lookup/3: PREDICATE

No further documentation available for this predicate.

list_lookup/4: PREDICATE

Usage: `list_lookup(List,Functor,Key,Value)`

– *Description:* Look up `Functor(Key,Value)` pair in variable ended key-value pair list `L` or else add it at the end.

intset_insert/3: PREDICATE

No further documentation available for this predicate.

intset_delete/3: PREDICATE

No further documentation available for this predicate.

intset_in/2: PREDICATE

No further documentation available for this predicate.

intset_sequence/3: PREDICATE

No further documentation available for this predicate.

intersection/3: PREDICATE

Usage: `intersection(+List1,+List2,-List)`

- *Description:* `List` has the elements which are both in `List1` and `List2`.

union/3: PREDICATE

Usage: `union(+List1,+List2,-List)`

- *Description:* `List` has the elements which are in `List1` followed by the elements which are in `List2` but not in `List1`.

difference/3: PREDICATE

Usage: `difference(+List1,+List2,-List)`

- *Description:* `List` has the elements which are in `List1` but not in `List2`.

sublist/2: PROPERTY

Usage: `sublist(List1,List2)`

- *Description:* `List2` contains all the elements of `List1`.
- *If the following properties should hold at call time:*

  `List2` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

subordlist/2: PROPERTY

Usage: `subordlist(List1,List2)`

- *Description:* `List2` contains all the elements of `List1` in the same order.
- *If the following properties should hold at call time:*

  `List2` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

equal_lists/2: PREDICATE

Usage: `equal_lists(+List1,+List2)`

- *Description:* `List1` has all the elements of `List2`, and vice versa.

list_to_list_of_lists/2: PREDICATE

Usage: `list_to_list_of_lists(+List,-LList)`

- *Description:* `LList` is the list of one element lists with elements of `List`.

powerset/2: PREDICATE

Usage: `powerset(+List,-LList)`

- *Description:* `LList` is the powerset of `List`, i.e., the list of all lists which have elements of `List`. If `List` is ordered, `LList` and all its elements are ordered.

43 Sorting lists

Author(s): Richard A. O'Keefe. All changes by UPM CLIP Group..
Version: 0.4#5 (1998/2/24)

43.1 Usage and interface (`sort`)

- **Library usage:**
  `:- use_module(library(sort)).`
- **Exports:**
  - *Predicates:*
    `sort/2`, `keysort/2`.
  - *Regular Types:*
    `keylist/1`.

43.2 Documentation on exports (`sort`)

sort/2: PREDICATE

`sort(List1,List2)`

The elements of `List1` are sorted into the standard order (see Chapter 18 [Comparing terms], page 105) and any identical elements are merged, yielding `List2`. The time and space complexity of this operation is at worst `O(N lg N)` where `N` is the length of `List1`.

Usage: `sort(+list,?list)`

- *Description:* `List2` is the sorted list corresponding to `List1`.

keysort/2: PREDICATE

`keysort(List1,List2)`

`List1` is sorted into order according to the value of the *keys* of its elements, yielding the list `List2`. No merging takes place. This predicate is *stable*, i.e., if an element `A` occurs before another element `B` *with the same key* in the input, then `A` will occur before `B` also in the output. The time and space complexity of this operation is at worst `O(N lg N)` where `N` is the length of `List1`.

Usage: `keysort(+keylist,?keylist)`

- *Description:* `List2` is the (key-)sorted list corresponding to `List1`.

keylist/1: REGTYPE

Usage: `keylist(L)`

- *Description:* `L` is a list of pairs of the form `Key-Value`.

43.3 Documentation on internals (`sort`)

keypair/1: REGTYPE

Usage: `keypair(P)`

– *Description:* `P` is a pair of the form `"K-_"`, where `K` is considered the *key*.

44 Dictionaries

Version: 1.7#139 (2001/11/12, 17:24:35 CET)

This module provides predicates for implementing dictionaries. Such dictionaries are currently implemented as ordered binary trees of key-value pairs.

44.1 Usage and interface (`dict`)

- **Library usage:**
  `:- use_module(library(dict)).`
- **Exports:**
  - *Predicates:*
    `dictionary/5`, `dic_node/2`, `dic_lookup/3`, `dic_lookup/4`, `dic_get/3`, `dic_replace/4`.
  - *Properties:*
    `dictionary/1`.

44.2 Documentation on exports (`dict`)

dictionary/1: PROPERTY

Usage: `dictionary(D)`

- *Description:* `D` is a dictionary.

dictionary/5: PREDICATE

Usage: `dictionary(D,K,V,L,R)`

- *Description:* The dictionary node `D` has key `K`, value `V`, left child `L`, and right child `R`.

dic_node/2: PREDICATE

Usage: `dic_node(D,N)`

- *Description:* `N` is a sub-dictionary of `D`.
- *Calls should, and exit will be compatible with:*
  `D` is a dictionary. (`dict:dictionary/1`)
  `N` is a dictionary. (`dict:dictionary/1`)

dic_lookup/3: PREDICATE

Usage: `dic_lookup(D,K,V)`

- *Description:* `D` contains value `V` at key `K`. If it was not already in `D` it is added.
- *Calls should, and exit will be compatible with:*
  `D` is a dictionary. (`dict:dictionary/1`)

dic_lookup/4: PREDICATE

Usage: `dic_lookup(D,K,V,O)`

- *Description:* Same as `dic_lookup(D,K,V)`. `O` indicates if it was already in `D` (`old`) or not (`new`).
- *Calls should, and exit will be compatible with:*

  `D` is a dictionary. (`dict:dictionary/1`)

dic_get/3: PREDICATE

Usage: `dic_get(D,K,V)`

- *Description:* `D` contains value `V` at key `K`. Fails if it is not already in `D`.
- *Calls should, and exit will be compatible with:*

  `D` is a dictionary. (`dict:dictionary/1`)

dic_replace/4: PREDICATE

Usage: `dic_replace(D,K,V,D1)`

- *Description:* `D` and `D1` are identical except for the element at key `K`, which in `D1` contains value `V`, whatever has (or whether it is) in `D`.
- *Calls should, and exit will be compatible with:*

  `D` is a dictionary. (`dict:dictionary/1`)

  `D1` is a dictionary. (`dict:dictionary/1`)

45 String processing

Author(s): Daniel Cabeza.

Version: 0.4#5 (1998/2/24)

This module provides predicates for doing input/output with strings (character code lists) and for including in grammars defining strings.

45.1 Usage and interface (strings)

- **Library usage:**

  `:- use_module(library(strings)).`
- **Exports:**
  - *Predicates:*

    `get_line/2`, `get_line/1`, `write_string/2`, `write_string/1`, `whitespace/2`, `whitespace0/2`, `string/3`.

45.2 Documentation on exports (strings)

get_line/2: PREDICATE

`get_line(Stream,Line)`

Reads from `Stream` a line of text and unifies `Line` with it. The end of the line can have UNIX [10] or MS-DOS [13 10] termination, which is not included in `Line`. At EOF, the term end_of_file is returned.

get_line/1: PREDICATE

`get_line(Line)`

Behaves like `current_input(S), get_line(S,Line)`.

write_string/2: PREDICATE

`write_string(Stream,String)`

Writes `String` onto `Stream`.

write_string/1: PREDICATE

`write_string(String)`

Behaves like `current_input(S), write_string(S, String)`.

whitespace/2: PREDICATE

`whitespace(String,Rest)`

In a grammar rule, as `whitespace/0`, represents whitespace (a positive number of space (32), tab (9), newline (10) or return (13) characters). Thus, `Rest` is a proper suffix of `String` with one or more whitespace characters removed. An example of use would be:

```
attrs([]) --> ""
attrs([N|Ns]) -->
    whitespace,
    attr(N),
    attrs(Ns).
```

whitespace0/2: PREDICATE

`whitespace0(String,Rest)`

In a grammar rule, as `whitespace0/0`, represents possible whitespace (any number of space (32), tab (9), newline (10) or return (13) characters). Thus, `Rest` is `String` or a proper suffix of `String` with one or more whitespace characters removed. An example of use would be:

```
assignment(N,V) -->
    variable_name(N), whitespace0, "=", whitespace0, value(V).
```

string/3: PREDICATE

`string(String,Head,Tail)`

In a grammar rule, as `string/1`, represents literally `String`. An example of use would be:

```
double(A) -->
        string(A),
        string(A).
```

45.3 Documentation on internals (strings)

line/1: PROPERTY

A property, defined as follows:

```
line(L) :-
        string(L).
line(end_of_file).
```

46 Formatted output

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.3#27 (1999/7/9, 20:25:50 MEST)

The `format` family of predicates is due to Quintus Prolog. They act as a Prolog interface to the C `stdio` function `printf()`, allowing formatted output.

Output is formatted according to an output pattern which can have either a format control sequence or any other character, which will appear verbatim in the output. Control sequences act as place-holders for the actual terms that will be output. Thus

```
?- format("Hello ~q!",world).
```

will print `Hello world!`.

If there is only one item to print it may be supplied alone. If there are more they have to be given as a list. If there are none then an empty list should be supplied. There has to be as many items as control characters.

The character ~ introduces a control sequence. To print a ~ verbatim just repeat it:

```
?- format("Hello ~~world!", []).
```

will result in `Hello ~world!`.

A format may be spread over several lines. The control sequence `\c` followed by a ⟨LFD⟩ will translate to the empty string:

```
?- format("Hello \c
world!", []).
```

will result in `Hello world!`.

46.1 Usage and interface (`format`)

- **Library usage:**
  `:- use_module(library(format)).`
- **Exports:**
  - *Predicates:*
    `format/2`, `format/3`.
  - *Regular Types:*
    `format_control/1`.
- **Other modules used:**
  - *System library modules:*
    `write`, `assertions/doc_props`.

46.2 Documentation on exports (`format`)

format/2: PREDICATE

Usage: `format(Format,Arguments)`

– *Description:* Print `Arguments` onto current output stream according to format `Format`.

– *Call and exit should be compatible with:*

`Format` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

format/3: PREDICATE

Usage: `format(+Stream,Format,Arguments)`

– *Description:* Print `Arguments` onto `Stream` according to format `Format`.

– *Call and exit should be compatible with:*

`Format` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

format_control/1: REGTYPE

The general format of a control sequence is `~NC`. The character `C` determines the type of the control sequence. `N` is an optional numeric argument. An alternative form of `N` is `*`. `*` implies that the next argument in `Arguments` should be used as a numeric argument in the control sequence. Example:

```
?- format("Hello~4cworld!", [0'x]).
```

and

```
?- format("Hello~*cworld!", [4,0'x]).
```

both produce

```
Helloxxxxworld!
```

The following control sequences are available.

- `~a` The argument is an atom. The atom is printed without quoting.
- `~Nc` (Print character.) The argument is a number that will be interpreted as an ASCII code. `N` defaults to one and is interpreted as the number of times to print the character.
- `~Ne`
- `~NE`
- `~Nf`
- `~Ng`
- `~NG` (Print float). The argument is a float. The float and `N` will be passed to the C `printf()` function as

```
printf("%.Ne", Arg)
printf("%.NE", Arg)
printf("%.Nf", Arg)
printf("%.Ng", Arg)
printf("%.NG", Arg)
```

If `N` is not supplied the action defaults to

```
printf("%e", Arg)
printf("%E", Arg)
printf("%f", Arg)
printf("%g", Arg)
printf("%G", Arg)
```

- ~Nd (Print decimal.) The argument is an integer. N is interpreted as the number of digits after the decimal point. If N is 0 or missing, no decimal point will be printed. Example:

```
?- format("Hello ~1d world!", [42]).
?- format("Hello ~d world!", [42]).
```

  will print as

```
Hello 4.2 world!
Hello 42 world!
```

  respectively.
- ~ND (Print decimal.) The argument is an integer. Identical to ~Nd except that , will separate groups of three digits to the left of the decimal point. Example:

```
?- format("Hello ~1D world!", [12345]).
```

  will print as

```
Hello 1,234.5 world!
```

- ~Nr (Print radix.) The argument is an integer. N is interpreted as a radix. N should be >= 2 and <= 36. If N is missing the radix defaults to 8. The letters a-z will denote digits larger than 9. Example:

```
?- format("Hello ~2r world!", [15]).
?- format("Hello ~16r world!", [15]).
```

  will print as

```
Hello 1111 world!
Hello f world!
```

  respectively.
- ~NR (Print radix.) The argument is an integer. Identical to ~Nr except that the letters A-Z will denote digits larger than 9. Example:

```
?- format("Hello ~16R world!", [15]).
```

  will print as

```
Hello F world!
```

- ~Ns (Print string.) The argument is a list of ASCII codes. Exactly N characters will be printed. N defaults to the length of the string. Example:

```
?- format("Hello ~4s ~4s!", ["new","world"]).
?- format("Hello ~s world!", ["new"]).
```

  will print as

```
Hello new  worl!
Hello new world!
```

  respectively.
- ~i (Ignore argument.) The argument may be of any type. The argument will be ignored. Example:

```
?- format("Hello ~i~s world!", ["old","new"]).
```

  will print as

```
Hello new world!
```

- ~k (Print canonical.) The argument may be of any type. The argument will be passed to write_canonical/2 (Chapter 34 [Term output], page 175). Example:

```
?- format("Hello ~k world!", [[a,b,c]]).
```

  will print as

```
Hello .(a,.(b,.(c,[]))) world!
```

- ~p (print.) The argument may be of any type. The argument will be passed to `print/2` (Chapter 34 [Term output], page 175). Example:

  suposing the user has defined the predicate

  ```
  :- multifile portray/1.
  portray([X|Y]) :- print(cons(X,Y)).
  ```

  then

  ```
  ?- format("Hello ~p world!", [[a,b,c]]).
  ```

  will print as

  ```
  Hello cons(a,cons(b,cons(c,[]))) world!
  ```

- ~q (Print quoted.) The argument may be of any type. The argument will be passed to `writeq/2` (Chapter 34 [Term output], page 175). Example:

  ```
  ?- format("Hello ~q world!", [['A','B']]).
  ```

  will print as

  ```
  Hello ['A','B'] world!
  ```

- ~w (write.) The argument may be of any type. The argument will be passed to `write/2` (Chapter 34 [Term output], page 175). Example:

  ```
  ?- format("Hello ~w world!", [['A','B']]).
  ```

  will print as

  ```
  Hello [A,B] world!
  ```

- ~Nn (Print newline.) Print `N` newlines. `N` defaults to 1. Example:

  ```
  ?- format("Hello ~n world!", []).
  ```

  will print as

  ```
  Hello
   world!
  ```

- ~N (Fresh line.) Print a newline, if not already at the beginning of a line.
- ~~ (Print tilde.) Prints ~

The following control sequences are also available for compatibility, but do not perform any useful functions.

- ~N| (Set tab.) Set a tab stop at position `N`, where `N` defaults to the current position, and advance the current position there.
- ~N+ (Advance tab.) Set a tab stop at `N` positions past the current position, where `N` defaults to 8, and advance the current position there.
- ~Nt (Set fill character.) Set the fill character to be used in the next position movement to `N`, where `N` defaults to ⟨SPC⟩.

Usage: `format_control(C)`

– *Description:* `C` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`.

– *The following properties should hold globally:*

Documentation is still incomplete: `format_control(C)` may not conform the functionality documented. (`doc_props:doc_incomplete/1`)

47 DEC-10 Prolog file IO

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 0.4#5 (1998/2/24)
This module implements the support for DEC-10 Prolog style file I/O.

47.1 Usage and interface (`dec10_io`)

- **Library usage:**
  `:- use_module(library(dec10_io)).`
- **Exports:**
  - *Predicates:*
    `see/1`, `seeing/1`, `seen/0`, `tell/1`, `telling/1`, `told/0`, `close_file/1`.
- **Other modules used:**
  - *System library modules:*
    `streams`.

47.2 Documentation on exports (`dec10_io`)

see/1: PREDICATE
No further documentation available for this predicate.

seeing/1: PREDICATE
No further documentation available for this predicate.

seen/0: PREDICATE
No further documentation available for this predicate.

tell/1: PREDICATE
No further documentation available for this predicate.

telling/1: PREDICATE
No further documentation available for this predicate.

told/0: PREDICATE
No further documentation available for this predicate.

close_file/1: PREDICATE
No further documentation available for this predicate.

48 ttyout (library)

Version: 0.4#5 (1998/2/24)

48.1 Usage and interface (ttyout)

- **Library usage:**
  `:- use_module(library(ttyout)).`
- **Exports:**
  - *Predicates:*
    `ttyget/1`, `ttyget1/1`, `ttynl/0`, `ttyput/1`, `ttyskip/1`, `ttytab/1`, `ttyflush/0`, `ttydisplay/1`, `ttydisplayq/1`, `ttyskipeol/0`, `ttydisplay_string/1`.

48.2 Documentation on exports (ttyout)

ttyget/1: PREDICATE

No further documentation available for this predicate.

ttyget1/1: PREDICATE

No further documentation available for this predicate.

ttynl/0: PREDICATE

No further documentation available for this predicate.

ttyput/1: PREDICATE

No further documentation available for this predicate.

ttyskip/1: PREDICATE

No further documentation available for this predicate.

ttytab/1: PREDICATE

No further documentation available for this predicate.

ttyflush/0: PREDICATE

No further documentation available for this predicate.

ttydisplay/1: PREDICATE

No further documentation available for this predicate.

ttydisplayq/1: PREDICATE

No further documentation available for this predicate.

ttyskipeol/0: PREDICATE

No further documentation available for this predicate.

ttydisplay_string/1: PREDICATE

No further documentation available for this predicate.

49 compiler (library)

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#176 (2002/1/14, 17:27:0 CET)

49.1 Usage and interface (compiler)

- **Library usage:**
  `:- use_module(library(compiler)).`
- **Exports:**
  - *Predicates:*
    `make_po/1`, `ensure_loaded/1`, `use_module/1`, `use_module/2`, `use_module/3`, `unload/1`, `set_debug_mode/1`, `set_nodebug_mode/1`, `set_debug_module/1`, `set_nodebug_module/1`, `set_debug_module_source/1`, `mode_of_module/2`, `module_of/2`.
- **Other modules used:**
  - *System library modules:*
    `compiler/c_itf`.

49.2 Documentation on exports (compiler)

make_po/1: PREDICATE
No further documentation available for this predicate.

ensure_loaded/1: PREDICATE
No further documentation available for this predicate.

use_module/1: PREDICATE
No further documentation available for this predicate.

use_module/2: PREDICATE
No further documentation available for this predicate.
Meta-predicate with arguments: `use_module(?,addmodule)`.

use_module/3: PREDICATE
No further documentation available for this predicate.

unload/1: PREDICATE
No further documentation available for this predicate.

set_debug_mode/1: PREDICATE

No further documentation available for this predicate.

set_nodebug_mode/1: PREDICATE

No further documentation available for this predicate.

set_debug_module/1: PREDICATE

No further documentation available for this predicate.

set_nodebug_module/1: PREDICATE

No further documentation available for this predicate.

set_debug_module_source/1: PREDICATE

No further documentation available for this predicate.

mode_of_module/2: PREDICATE

No further documentation available for this predicate.

module_of/2: PREDICATE

No further documentation available for this predicate.

50 Quintus-like internal database

Version: 0.4#5 (1998/2/24)

The predicates described in this section were introduced in early implementations of Prolog to provide efficient means of performing operations on large quantities of data. The introduction of indexed dynamic predicates have rendered these predicates obsolete, and the sole purpose of providing them is to support existing code. There is no reason whatsoever to use them in new code.

These predicates store arbitrary terms in the database without interfering with the clauses which make up the program. The terms which are stored in this way can subsequently be retrieved via the key on which they were stored. Many terms may be stored on the same key, and they can be individually accessed by pattern matching. Alternatively, access can be achieved via a special identifier which uniquely identifies each recorded term and which is returned when the term is stored.

50.1 Usage and interface (`old_database`)

- **Library usage:**
  `:- use_module(library(old_database)).`
- **Exports:**
  - *Predicates:*
    `recorda/3`, `recordz/3`, `recorded/3`, `current_key/2`.

50.2 Documentation on exports (`old_database`)

recorda/3: PREDICATE

`recorda(+Key,?Term,-Ref)`

The term `Term` is recorded in the internal database as the first item for the key `Key`, where `Ref` is its implementation-defined identifier. The key must be given, and only its principal functor is significant. Any uninstantiated variables in the `Term` will be replaced by new private variables, along with copies of any subgoals blocked on these variables.

recordz/3: PREDICATE

`recordz(+Key,?Term,-Ref)`

Like `recorda/3`, except that the new term becomes the *last* item for the key `Key`.

recorded/3: PREDICATE

`recorded(?Key,?Term,?Ref)`

The internal database is searched for terms recorded under the key `Key`. These terms are successively unified with `Term` in the order they occur in the database. At the same time, `Ref` is unified with the implementation-defined identifier uniquely identifying the recorded item. If the key is instantiated to a compound term, only its principal functor is significant. If the key is uninstantiated, all terms in the database are successively unified with `Term` in the order they occur.

current_key/2: PREDICATE

`current_key(?KeyName,?KeyTerm)`

`KeyTerm` is the most general form of the key for a currently recorded term, and `KeyName` is the name of that key. This predicate can be used to enumerate in undefined order all keys for currently recorded terms through backtracking.

51 Enabling operators at run-time

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Version of last change: 1.7#140 (2001/11/12, 17:27:51 CET)

This library package allows the use of the statically defined operators of a module for the reading performed at run-time by the program that uses the module. Simply by using this package the operator definitions appearing in the module are enabled during the execution of the program.

51.1 Usage and interface (`runtime_ops`)

- **Library usage:**

  ```
  :- use_package(runtime_ops).
  ```

  or

  ```
  :- module(...,...,[runtime_ops]).
  ```

- **Other modules used:**
  - *System library modules:*

    `operators`.

PART V - Annotated Prolog library (assertions)

Ciao allows *annotating* the program code with *assertions*. Such assertions include type and instantiation mode declarations, but also more general properties as well as comments in the style of the *literate programming*. These assertions document predicates (and modules and whole applications) and can be used by the Ciao preprocessor/compiler while debugging and optimizing the program or library, and by the Ciao documenter to build the program or library reference manual.

52 The Ciao assertion package

Author(s): Manuel Hermenegildo, Francisco Bueno, German Puebla.

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Version of last change: 1.5#8 (1999/12/9, 21:1:11 MET)

The `assertions` package adds a number of new declaration definitions and new operator definitions which allow including program assertions in user programs. Such assertions can be used to describe predicates, properties, modules, applications, etc. These descriptions can be formal specifications (such as preconditions and post-conditions) or machine-readable textual comments.

This module is part of the `assertions` library. It defines the basic code-related assertions, i.e., those intended to be used mainly by compilation-related tools, such as the static analyzer or the run-time test generator.

Giving specifications for predicates and other program elements is the main functionality documented here. The exact syntax of comments is described in the autodocumenter (`lpdoc` [Knu84,Her99]) manual, although some support for adding machine-readable comments in assertions is also mentioned here.

There are two kinds of assertions: predicate assertions and program point assertions. All predicate assertions are currently placed as directives in the source code, i.e., preceded by ":-". Program point assertions are placed as goals in clause bodies.

52.1 More info

The facilities provided by the library are documented in the description of its component modules. This documentation is intended to provide information only at a "reference manual" level. For a more tutorial introduction to the subject and some more examples please see the document "An Assertion Language for Debugging of Constraint Logic Programs (Technical Report CLIP2/97.1)". The assertion language implemented in this library is modeled after this design document, although, due to implementation issues, it may differ in some details. The purpose of this manual is to document precisely what the implementation of the library supports at any given point in time.

52.2 Some attention points

- **Formatting commands within text strings:** many of the predicates defined in these modules include arguments intended for providing textual information. This includes titles, descriptions, comments, etc. The type of this argument is a character string. In order for the automatic generation of documentation to work correctly, this character string should adhere to certain conventions. See the description of the `docstring/1` type/grammar for details.
- **Referring to variables:** In order for the automatic documentation system to work correctly, variable names (for example, when referring to arguments in the head patterns of *pred* declarations) must be surrounded by an `@var` command. For example, `@var{VariableName}` should be used for referring to the variable "VariableName", which will appear then formatted as follows: `VariableName`. See the description of the `docstring/1` type/grammar for details.

52.3 Usage and interface (assertions)

- **Library usage:**
  The recommended procedure in order to make use of assertions in user programs is to include the `assertions` syntax library, using one of the following declarations, as appropriate:

```
:- module(...,...,[assertions]).
:- include(library(assertions)).
:- use_package([assertions]).
```

- **Exports:**
  - *Predicates:*
    `check/1`, `trust/1`, `true/1`, `false/1`.
- **New operators defined:**
  `=>/2` [975,xfx], `::/2` [978,xfx], `decl/1` [1150,fx], `decl/2` [1150,xfx], `pred/1` [1150,fx], `pred/2` [1150,xfx], `prop/1` [1150,fx], `prop/2` [1150,xfx], `modedef/1` [1150,fx], `calls/1` [1150,fx], `calls/2` [1150,xfx], `success/1` [1150,fx], `success/2` [1150,xfx], `comp/1` [1150,fx], `comp/2` [1150,xfx], `entry/1` [1150,fx].
- **New declarations defined:**
  `pred/1`, `pred/2`, `calls/1`, `calls/2`, `success/1`, `success/2`, `comp/1`, `comp/2`, `prop/1`, `prop/2`, `entry/1`, `modedef/1`, `decl/1`, `decl/2`, `comment/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/assertions_props`.

52.4 Documentation on new declarations (assertions)

pred/1: DECLARATION

This assertion provides information on a predicate. The body of the assertion (its only argument) contains properties or comments in the formats defined by `assrt_body/1`.

More than one of these assertions may appear per predicate, in which case each one represents a possible " mode" of use (usage) of the predicate. The exact scope of the usage is defined by the properties given for calls in the body of each assertion (which should thus distinguish the different usages intended). All of them together cover all possible modes of usage.

For example, the following assertions describe (all the and the only) modes of usage of predicate `length/2` (see `lists`):

```
:- pred length(L,N) : list * var => list * integer
# "Computes the length of L.".
:- pred length(L,N) : var * integer => list * integer
# "Outputs L of length N.".
:- pred length(L,N) : list * integer => list * integer
# "Checks that L is of length N.".
```

Usage: `:- pred(AssertionBody).`

- *The following properties should hold at call time:*
  `AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

pred/2: DECLARATION

This assertion is similar to a `pred/1` assertion but it is explicitely qualified. Non-qualified `pred/1` assertions are assumed the qualifier `check`.

Usage: :- `pred(AssertionStatus,AssertionBody)`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

calls/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it only provides information about the calls to a predicate. If one or several calls assertions are given they are understood to describe all possible calls to the predicate.

For example, the following assertion describes all possible calls to predicate `is/2` (see `arithmetic`):

```
:- calls is(term,arithexpression).
```

Usage: :- `calls(AssertionBody)`.

– *The following properties should hold at call time:*

`AssertionBody` is a call assertion body. (`assertions_props:c_assrt_body/1`)

calls/2: DECLARATION

This assertion is similar to a `calls/1` assertion but it is explicitely qualified. Non-qualified `calls/1` assertions are assumed the qualifier `check`.

Usage: :- `calls(AssertionStatus,AssertionBody)`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)

`AssertionBody` is a call assertion body. (`assertions_props:c_assrt_body/1`)

success/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it only provides information about the answers to a predicate. The described answers might be conditioned to a particular way of calling the predicate.

For example, the following assertion specifies the answers of the `length/2` predicate *if* it is called as in the first mode of usage above (note that the previous pred assertion already conveys such information, however it also compelled the predicate calls, while the success assertion does not):

```
:- success length(L,N) : list * var => list * integer.
```

Usage: :- `success(AssertionBody)`.

– *The following properties should hold at call time:*

`AssertionBody` is a predicate assertion body. (`assertions_props:s_assrt_body/1`)

success/2: DECLARATION

This assertion is similar to a `success/1` assertion but it is explicitely qualified. Non-qualified `success/1` assertions are assumed the qualifier `check`.

Usage: :- `success(AssertionStatus,AssertionBody).`

— *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)

`AssertionBody` is a predicate assertion body. (`assertions_props:s_assrt_body/1`)

comp/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it only provides information about the global execution properties of a predicate (note that such kind of information is also conveyed by pred assertions). The described properties might be conditioned to a particular way of calling the predicate.

For example, the following assertion specifies that the computation of `append/3` (see `lists`) will not fail *if* it is called as described (but does not compel the predicate to be called that way):

```
:- comp append(Xs,Ys,Zs) : var * var * var + not_fail.
```

Usage: :- `comp(AssertionBody).`

— *The following properties should hold at call time:*

`AssertionBody` is a comp assertion body. (`assertions_props:g_assrt_body/1`)

comp/2: DECLARATION

This assertion is similar to a `comp/1` assertion but it is explicitely qualified. Non-qualified `comp/1` assertions are assumed the qualifier `check`.

Usage: :- `comp(AssertionStatus,AssertionBody).`

— *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)

`AssertionBody` is a comp assertion body. (`assertions_props:g_assrt_body/1`)

prop/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it flags that the predicate being documented is also a " property."

Properties are standard predicates, but which are *guaranteed to terminate for any possible instantiation state of their argument(s)*, do not perform side-effects which may interfere with the program behaviour, and do not further instantiate their arguments or add new constraints.

Provided the above holds, properties can thus be safely used as run-time checks. The program transformation used in `ciaopp` for run-time checking guarantees the third requirement. It also performs some basic checks on properties which in most cases are enough for the second requirement. However, it is the user's responsibility to guarantee termination of the properties defined. (See also Chapter 54 [Declaring regular types], page 241 for some considerations applicable to writing properties.)

The set of properties is thus a strict subset of the set of predicates. Note that properties can be used to describe characteristics of arguments in assertions and they can also be executed (called) as any other predicates.

Usage: :- `prop(AssertionBody)`.

— *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

prop/2: DECLARATION

This assertion is similar to a `prop/1` assertion but it is explicitely qualified. Non-qualified `prop/1` assertions are assumed the qualifier `check`.

Usage: :- `prop(AssertionStatus,AssertionBody)`.

— *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

entry/1: DECLARATION

This assertion provides information about the *external* calls to a predicate. It is identical syntactically to a `calls/1` assertion. However, they describe only external calls, i.e., calls to the exported predicates of a module from outside the module, or calls to the predicates in a non-modular file from other files (or the user).

These assertions are *trusted* by the compiler. As a result, if their descriptions are erroneous they can introduce bugs in programs. Thus, `entry/1` assertions should be written with care.

An important use of these assertions is in providing information to the compiler which it may not be able to infer from the program. The main use is in providing information on the ways in which exported predicates of a module will be called from outside the module. This will greatly improve the precision of the analyzer, which otherwise has to assume that the arguments that exported predicates receive are any arbitrary term.

Usage: :- `entry(AssertionBody)`.

— *The following properties should hold at call time:*

`AssertionBody` is a call assertion body. (`assertions_props:c_assrt_body/1`)

modedef/1: DECLARATION

This assertion is used to define modes. A mode defines in a compact way a set of call and success properties. Once defined, modes can be applied to predicate arguments in assertions. The meaning of this application is that the call and success properties defined by the mode hold for the argument to which the mode is applied. Thus, a mode is conceptually a "property macro".

The syntax of mode definitions is similar to that of pred declarations. For example, the following set of assertions:

```
:- modedef +A : nonvar(A) # "A is bound upon predicate entry.".

:- pred p(+A,B) : integer(A) =>  ground(B).
```

is equivalent to:

```
:- pred p(A,B) : (nonvar(A),integer(A)) =>  ground(B)
   # "A is bound upon predicate entry.".
```

Usage: :- `modedef(AssertionBody)`.

– *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

decl/1: DECLARATION

This assertion is similar to a `pred/1` assertion but it is used for declarations instead than for predicates.

Usage: :- `decl(AssertionBody)`.

– *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

decl/2: DECLARATION

This assertion is similar to a `decl/1` assertion but it is explicitely qualified. Non-qualified `decl/1` assertions are assumed the qualifier `check`.

Usage: :- `decl(AssertionStatus,AssertionBody)`.

– *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

comment/2: DECLARATION

Usage: :- `comment(Pred,Comment)`.

– *Description:* This assertion gives a text `Comment` for a given predicate `Pred`.

– *The following properties should hold at call time:*

`Pred` is a head pattern. (`assertions_props:head_pattern/1`)

`Comment` is a text comment with admissible documentation commands. The usual formatting commands that are applicable in comment strings are defined by `stringcommand/1`. See the `lpdoc` manual for documentation on comments. (`assertions_props:docstring/1`)

52.5 Documentation on exports (`assertions`)

check/1: PREDICATE

Usage: `check(PropertyConjunction)`

– *Description:* This assertion provides information on a clause program point (position in the body of a clause). Calls to a `check/1` assertion can appear in the body of a clause in any place where a literal can normally appear. The property defined by `PropertyConjunction` should hold in all the run-time stores corresponding to that program point. See also Chapter 59 [Run-time checking of assertions], page 259.

– *The following properties should hold at call time:*

`PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (`assertions_props:property_conjunction/1`)

trust/1: PREDICATE

Usage: `trust(PropertyConjunction)`

– *Description:* This assertion also provides information on a clause program point. It is identical syntactically to a `check/1` assertion. However, the properties stated are not taken as something to be checked but are instead *trusted* by the compiler. While the compiler may in some cases detect an inconsistency between a `trust/1` assertion and the program, in all other cases the information given in the assertion will be taken to be true. As a result, if these assertions are erroneous they can introduce bugs in programs. Thus, `trust/1` assertions should be written with care.

An important use of these assertions is in providing information to the compiler which it may not be able to infer from the program (either because the information is not present or because the analyzer being used is not precise enough). In particular, providing information on external predicates which may not be accessible at the time of compiling the module can greatly improve the precision of the analyzer. This can be easily done with trust assertion.

– *The following properties should hold at call time:*

`PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (`assertions_props:property_conjunction/1`)

true/1: PREDICATE

Usage: `true(PropertyConjunction)`

– *Description:* This assertion is identical syntactically to a `check/1` assertion. However, the properties stated have been proved to hold by the analyzer. Thus, these assertions often represent the analyzer output.

– *The following properties should hold at call time:*

`PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (`assertions_props:property_conjunction/1`)

false/1: PREDICATE

Usage: `false(PropertyConjunction)`

– *Description:* This assertion is identical syntactically to a `check/1` assertion. However, the properties stated have been proved not to hold by the analyzer. Thus, these assertions often represent the analyzer output.

– *The following properties should hold at call time:*

`PropertyConjunction` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument. (`assertions_props:property_conjunction/1`)

53 Types and properties related to assertions

Author(s): Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#156 (2001/11/24, 13:23:30 CET)

This module is part of the `assertions` library. It provides the formal definition of the syntax of several forms of assertions and describes their meaning. It does so by defining types and properties related to the assertions themselves. The text describes, for example, the overall fields which are admissible in the bodies of assertions, where properties can be used inside these bodies, how to combine properties for a given predicate argument (e.g., conjunctions) , etc. and provides some examples.

53.1 Usage and interface (`assertions_props`)

- **Library usage:**

  `:- use_module(library(assertions_props)).`
- **Exports:**
  - *Properties:*

    `head_pattern/1`, `nabody/1`, `docstring/1`.
  - *Regular Types:*

    `assrt_body/1`, `complex_arg_property/1`, `property_conjunction/1`, `property_starterm/1`, `complex_goal_property/1`, `dictionary/1`, `c_assrt_body/1`, `s_assrt_body/1`, `g_assrt_body/1`, `assrt_status/1`, `assrt_type/1`, `predfunctor/1`, `propfunctor/1`.
- **Other modules used:**
  - *System library modules:*

    `dcg_expansion`.

53.2 Documentation on exports (`assertions_props`)

assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `pred/1`, `decl/1`, etc. assertions. Such a body is of the form:

```
Pr [:: DP] [: CP] [=> AP] [+ GP] [# CO]
```

where (fields between [...] are optional):

- `Pr` is a head pattern (`head_pattern/1`) which describes the predicate or property and possibly gives some implicit call/answer information.
- `DP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which expresses properties which are compatible with the predicate, i.e., instantiations made by the predicate are *compatible* with the properties in the sense that applying the property at any point to would not make it fail.
- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.

- `AP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *answers* to the predicate (if the predicate succeeds). These only apply if the (possibly empty) properties given for calls in the assertion hold.
- `GP` is a (possibly empty) complex goal property (`complex_goal_property/1`) which applies to the *whole execution* of a call to the predicate. These only apply if the (possibly empty) properties given for calls in the assertion hold.
- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

  See the `lpdoc` manual for documentation on assertion comments.

Usage: `assrt_body(X)`

– *Description:* `X` is an assertion body.

head_pattern/1: PROPERTY

A head pattern can be a predicate name (functor/arity) (`predname/1`) or a term. Thus, both `p/3` and `p(A,B,C)` are valid head patterns. In the case in which the head pattern is a term, each argument of such a term can be:

- A variable. This is useful in order to be able to refer to the corresponding argument positions by name within properties and in comments. Thus, `p(Input,Parameter,Output)` is a valid head pattern.
- A ground term. In this case this term determines a property of the corresponding argument. The actual property referred to is that given by the term but with one more argument added at the beginning, which is a new variable which, in a rewriting of the head pattern, appears at the argument position occupied by the term. Unless otherwise stated (see below), the property built this way is understood to hold for both calls and answers. For example, the head pattern `p(Input,list(integer),Output)` is valid and equivalent for example to having the head pattern `p(Input,A,Output)` and stating that the property `list(A,integer)` holds for the calls and successes of the predicate.
- Finally, it can also be a variable or a ground term, as above, but preceded by a " mode." This mode determines in a compact way certain call or answer properties. For example, the head pattern `p(Input,+list(integer),Output)` is valid, as long as `+/1` is declared as a mode.

  Acceptable modes are documented in `library(modes)`. User defined modes are documented in `modedef/1`.

Usage: `head_pattern(Pr)`

– *Description:* `Pr` is a head pattern.

complex_arg_property/1: REGTYPE

`complex_arg_property(Props)`

`Props` is a (possibly empty) complex argument property. Such properties can appear in two formats, which are defined by `property_conjunction/1` and `property_starterm/1` respectively. The two formats can be mixed provided they are not in the same field of an assertion. I.e., the following is a valid assertion:

```
:- pred foo(X,Y) : nonvar * var => (ground(X),ground(Y)).
```

Usage: `complex_arg_property(Props)`

– *Description:* `Props` is a (possibly empty) complex argument property

property_conjunction/1: REGTYPE

This type defines the first, unabridged format in which properties can be expressed in the bodies of assertions. It is essentially a conjunction of properties which refer to variables. The following is an example of a complex property in this format:

- `(integer(X),list(Y,integer))`: `X` has the property `integer/1` and `Y` has the property `list/2`, with second argument `integer`.

Usage: `property_conjunction(Props)`

– *Description:* `Props` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. The first argument of each such term is a variable which appears as a head argument.

property_starterm/1: REGTYPE

This type defines a second, compact format in which properties can be expressed in the bodies of assertions. A `property_starterm/1` is a term whose main functor is `*/2` and, when it appears in an assertion, the number of terms joined by `*/2` is exactly the arity of the predicate it refers to. A similar series of properties as in `property_conjunction/1` appears, but the arity of each property is one less: the argument position to which they refer (first argument) is left out and determined by the position of the property in the `property_starterm/1`. The idea is that each element of the `*/2` term corresponds to a head argument position. Several properties can be assigned to each argument position by grouping them in curly brackets. The following is an example of a complex property in this format:

- `integer * list(integer)`: the first argument of the procedure (or function, or ...) has the property `integer/1` and the second one has the property `list/2`, with second argument `integer`.
- `{integer,var} * list(integer)`: the first argument of the procedure (or function, or ...) has the properties `integer/1` and `var/1` and the second one has the property `list/2`, with second argument `integer`.

Usage: `property_starterm(Props)`

– *Description:* `Props` is either a term or several terms separated by `*/2`. The main functor of each of those terms corresponds to that of the definition of a property, and the arity should be one less than in the definition of such property. All arguments of each such term are ground.

complex_goal_property/1: REGTYPE

`complex_goal_property(Props)`

`Props` is a (possibly empty) complex goal property. Such properties can be either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. Such properties apply to all executions of all goals of the predicate which comply with the assertion in which the `Props` appear.

The arguments of the terms in `Props` are implicitely augmented with a first argument which corresponds to a goal of the predicate of the assertion in which the `Props` appear. For example, the assertion

```
:- comp var(A) + not_further_inst(A).
```

has property `not_further_inst/1` as goal property, and establishes that in all executions of `var(A)` it should hold that `not_further_inst(var(A),A)`.

Usage: `complex_goal_property(Props)`

– *Description:* `Props` is either a term or a *conjunction* of terms. The main functor and arity of each of those terms corresponds to the definition of a property. A first implicit argument in such terms identifies goals to which the properties apply.

nabody/1: PROPERTY

Usage: `nabody(ABody)`

– *Description:* `ABody` is a normalized assertion body.

dictionary/1: REGTYPE

Usage: `dictionary(D)`

– *Description:* `D` is a dictionary of variable names.

c_assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `call/1`, `entry/1`, etc. assertions. The following are admissible:

```
Pr : CP [# CO]
```

where (fields between [...] are optional):

- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.
- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

The format of the different parts of the assertion body are given by `n_assrt_body/5` and its auxiliary types.

Usage: `c_assrt_body(X)`

– *Description:* `X` is a call assertion body.

s_assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `pred/1`, `func/1`, etc. assertions. The following are admissible:

```
Pr : CP => AP # CO
Pr : CP => AP
Pr => AP # CO
Pr => AP
```

where:

- `Pr` is a head pattern (`head_pattern/1`) which describes the predicate or property and possibly gives some implicit call/answer information.
- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.
- `AP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *answers* to the predicate (if the predicate succeeds). These only apply if the (possibly empty) properties given for calls in the assertion hold.

- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

The format of the different parts of the assertion body are given by `n_assrt_body/5` and its auxiliary types.

Usage: `s_assrt_body(X)`

– *Description:* `X` is a predicate assertion body.

g_assrt_body/1: REGTYPE

This predicate defines the different types of syntax admissible in the bodies of `comp/1` assertions. The following are admissible:

```
Pr : CP + GP # CO
Pr : CP + GP
Pr + GP # CO
Pr + GP
```

where:

- `Pr` is a head pattern (`head_pattern/1`) which describes the predicate or property and possibly gives some implicit call/answer information.
- `CP` is a (possibly empty) complex argument property (`complex_arg_property/1`) which applies to the *calls* to the predicate.
- `GP` contains (possibly empty) complex goal property (`complex_goal_property/1`) which applies to the *whole execution* of a call to the predicate. These only apply if the (possibly empty) properties given for calls in the assertion hold.
- `CO` is a comment string (`docstring/1`). This comment only applies if the (possibly empty) properties given for calls in the assertion hold. The usual formatting commands that are applicable in comment strings can be used (see `stringcommand/1`).

The format of the different parts of the assertion body are given by `n_assrt_body/5` and its auxiliary types.

Usage: `g_assrt_body(X)`

– *Description:* `X` is a comp assertion body.

assrt_status/1: REGTYPE

The types of assertion status. They have the same meaning as the program-point assertions, and are as follows:

```
assrt_status(true).
assrt_status(false).
assrt_status(check).
assrt_status(checked).
assrt_status(trust).
```

Usage: `assrt_status(X)`

– *Description:* `X` is an acceptable status for an assertion.

assrt_type/1: REGTYPE

The admissible kinds of assertions:

```
assrt_type(pred).
assrt_type(prop).
assrt_type(decl).
assrt_type(func).
assrt_type(calls).
assrt_type(success).
assrt_type(comp).
assrt_type(entry).
assrt_type(modedef).
```

Usage: `assrt_type(X)`

- *Description:* `X` is an admissible kind of assertion.

predfunctor/1: REGTYPE

Usage: `predfunctor(X)`

- *Description:* `X` is a type of assertion which defines a predicate.

propfunctor/1: REGTYPE

Usage: `propfunctor(X)`

- *Description:* `X` is a type of assertion which defines a *property*.

docstring/1: PROPERTY

Usage: `docstring(String)`

- *Description:* `String` is a text comment with admissible documentation commands. The usual formatting commands that are applicable in comment strings are defined by `stringcommand/1`. See the `lpdoc` manual for documentation on comments.

54 Declaring regular types

Author(s): Manuel Hermenegildo, Pedro Lopez, Francisco Bueno.

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This library package adds some new declaration definitions and new operator definitions to user programs. These new declarations and operators provide some very simple syntactic sugar to support regular type definitions in source code. Regular types are just properties which have the additional characteristic of being regular types (`basic_props:regtype/1`).

For example, this library package allows writing:

```
:- regtype tree(X) # "X is a tree.".
```

instead of the more combersome:

```
:- prop tree(X) + regtype # "X is a tree.".
```

Regular types can be used as properties to describe predicates and play an essential role in program debugging (see the Ciao Prolog preprocessor (`ciaopp`) manual).

In this chapter we explain some general considerations worth taking into account when writing properties in general, not just regular types. The exact syntax of regular types is also described.

54.1 Defining properties

Given the classes of assertions in the Ciao assertion language, there are two fundamental classes of properties. Properties used in assertions which refer to execution states (i.e., `calls/1`, `success/1`, and the like) are called *properties of execution states*. Properties used in assertions related to computations (i.e., `comp/1`) are called *properties of computations*. Different considerations apply when writing a property of the former or of the later kind.

Consider a definition of the predicate `string_concat/3` which concatenates two character strings (represented as lists of ASCII codes):

```
string_concat([],L,L).
string_concat([X|Xs],L,[X|NL]):- string_concat(Xs,L,NL).
```

Assume that we would like to state in an assertion that each argument "is a list of integers." However, we must decide which one of the following two possibilities we mean exactly: "the argument is *instantiated* to a list of integers" (let us call this property `instantiated_to_intlist/1`), or "if any part of the argument is instantiated, this instantiation must be compatible with the argument being a list of integers" (we will call this property `compatible_with_intlist/1`). For example, `instantiated_to_intlist/1` should be true for the terms `[]` and `[1,2]`, but should not for `X`, `[a,2]`, and `[X,2]`. In turn, `compatible_with_intlist/1` should be true for `[]`, `X`, `[1,2]`, and `[X,2]`, but should not be for `[X|1]`, `[a,2]`, and `1`. We refer to properties such as `instantiated_to_intlist/1` above as *instantiation properties* and to those such as `compatible_with_intlist/1` as *compatibility properties* (corresponding to the traditional notions of "instantiation types" and "compatibility types").

It turns out that both of these notions are quite useful in practice. In the example above, we probably would like to use `compatible_with_intlist/1` to state that on success of `string_concat/3` all three argument must be compatible with lists of integers in an assertion like:

```
:- success string_concat(A,B,C) => ( compatible_with_intlist(A),
                                     compatible_with_intlist(B),
                                     compatible_with_intlist(C) ).
```

With this assertion, no error will be flagged for a call to `string_concat/3` such as `string_concat([20],L,R)`, which on success produces the resulting atom `string_concat([20],L,[20|L])`, but a call `string_concat([],a,R)` would indeed flag an error.

On the other hand, and assuming that we are running on a Prolog system, we would probably like to use `instantiated_to_intlist/1` for `sumlist/2` as follows:

```
:- calls sumlist(L,N) : instantiated_to_intlist(L).

sumlist([],0).
sumlist([X|R],S) :- sumlist(R,PS), S is PS+X.
```

to describe the type of calls for which the program has been designed, i.e., those in which the first argument of `sumlist/2` is indeed a list of integers.

The property `instantiated_to_intlist/1` might be written as in the following (Prolog) definition:

```
:- prop instantiated_to_intlist/1.

instantiated_to_intlist(X) :-
       nonvar(X), instantiated_to_intlist_aux(X).

instantiated_to_intlist_aux([]).
instantiated_to_intlist_aux([X|T]) :-
       integer(X), instantiated_to_intlist(T).
```

(Recall that the Prolog builtin `integer/1` itself implements an instantiation check, failing if called with a variable as the argument.)

The property `compatible_with_intlist/1` might in turn be written as follows (also in Prolog):

```
:- prop compatible_with_intlist/1.

compatible_with_intlist(X) :- var(X).
compatible_with_intlist(X) :-
       nonvar(X), compatible_with_intlist_aux(X).

compatible_with_intlist_aux([]).
compatible_with_intlist_aux([X|T]) :-
       int_compat(X), compatible_with_intlist(T).

int_compat(X) :- var(X).
int_compat(X) :- nonvar(X), integer(X).
```

Note that these predicates meet the criteria for being properties and thus the `prop/1` declaration is correct.

Ensuring that a property meets the criteria for "not affecting the computation" can sometimes make its coding somewhat tedious. In some ways, one would like to be able to write simply:

```
intlist([]).
intlist([X|R]) :- int(X), intlist(R).
```

(Incidentally, note that the above definition, provided that it suits the requirements for being a property and that `int/1` is a regular type, meets the criteria for being a regular type. Thus, it could be declared `:- regtype intlist/1.`)

But note that (independently of the definition of `int/1`) the definition above is not the correct instantiation check, since it would succeed for a call such as `intlist(X)`. In fact, it is not strictly correct as a compatibility property either, because, while it would fail or succeed

as expected, it would perform instantiations (e.g., if called with `intlist(X)` it would bind `X` to `[]`). In practice, it is convenient to provide some run-time support to aid in this task.

The run-time support of the Ciao system (see Chapter 59 [Run-time checking of assertions], page 259) ensures that the execution of properties is performed in such a way that properties written as above can be used directly as instantiation checks. Thus, writing:

```
:- calls sumlist(L,N) : intlist(L).
```

has the desired effect. Also, the same properties can often be used as compatibility checks by writing them in the assertions as `compat(Property)` (`basic_props:compat/1`). Thus, writing:

```
:- success string_concat(A,B,C) => ( compat(intlist(A)),
                                     compat(intlist(B)),
                                     compat(intlist(C)) ).
```

also has the desired effect.

As a general rule, the properties that can be used directly for checking for compatibility should be *downwards closed*, i.e., once they hold they will keep on holding in every state accessible in forwards execution. There are certain predicates which are inherently *instantiation* checks and should not be used as *compatibility* properties nor appear in the definition of a property that is to be used with `compat`. Examples of such predicates (for Prolog) are `==`, `ground`, `nonvar`, `integer`, `atom`, `>`, etc. as they require a certain instantiation degree of their arguments in order to succeed.

In contrast with properties of execution states, *properties of computations* refer to the entire execution of the call(s) that the assertion relates to. One such property is, for example, `not_fail/1` (note that although it has been used as in `:- comp append(Xs,Ys,Zs) + not_fail`, it is in fact read as `not_fail(append(Xs,Ys,Zs))`; see `assertions_props:complex_goal_property/1`). For this property, which should be interpreted as "execution of the predicate either succeeds at least once or loops," we can use the following predicate `not_fail/1` for run-time checking:

```
not_fail(Goal):-
      if( call(Goal),
          true,            %% then
          warning(Goal) ). %% else
```

where the `warning/1` (library) predicate simply prints a warning message.

In this simple case, implementation of the predicate is not very difficult using the (non-standard) `if/3` builtin predicate present in many Prolog systems.

However, it is not so easy to code predicates which check other properties of the computation and we may in general need to program a meta-interpreter for this purpose.

54.2 Usage and interface (regtypes)

- **Library usage:**
  `:- use_package(regtypes).`
  or
  `:- module(...,...,[regtypes]).`
- **New operators defined:**
  `regtype/1` [1150,fx], `regtype/2` [1150,xfx].
- **New declarations defined:**
  `regtype/1`, `regtype/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/assertions_props`.

54.3 Documentation on new declarations (regtypes)

regtype/1: DECLARATION

This assertion is similar to a pred assertion but it flags that the predicate being documented is also a " regular type." This allows for example checking whether it is in the class of types supported by the type checking and inference modules. Currently, types are properties whose definitions are *regular programs*.

A regular program is defined by a set of clauses, each of the form:

```
p(x, v_1, ..., v_n)  :- body_1, ..., body_k.
```

where:

1. `x` is a term whose variables (which are called *term variables*) are unique, i.e., it is not allowed to introduce equality constraints between the variables of `x`.
   For example, `p(f(X, Y)) :- ...` is valid, but `p(f(X, X)) :- ...` is not.
2. in all clauses defining `p/n+1` the terms `x` do not unify except maybe for one single clause in which `x` is a variable.
3. `n` >= 0 and `p/n` is a *parametric type functor* (whereas the predicate defined by the clauses is `p/n+1`).
4. `v_1`, ..., `v_n` are unique variables, which are called *parametric variables*.
5. Each `body_i` is of the form:
   1. `t(z)` where `z` is one of the *term variables* and `t` is a *regular type expression*;
   2. `q(y, t_1, ..., t_m)` where `m` >= 0, `q/m` is a *parametric type functor*, not in the set of functors `=/2`, `^/2`, `./3`.
      `t_1, ..., t_m` are *regular type expressions*, and `y` is a *term variable*.
6. Each term variable occurs at most once in the clause's body (and should be as the first argument of a literal).

A *regular type expression* is either a parametric variable or a parametric type functor applied to some of the parametric variables (but regular type abstractions might also be used in some cases, see Chapter 56 [Meta-properties], page 251).

A parametric type functor is a regular type, defined by a regular program, or a basic type. Basic types are defined in Chapter 15 [Basic data types and properties], page 93.

The set of types is thus a well defined subset of the set of properties. Note that types can be used to describe characteristics of arguments in assertions and they can also be executed (called) as any other predicates.

Usage: `:- regtype(AssertionBody).`

— *The following properties should hold at call time:*

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

regtype/2: DECLARATION

This assertion is similar to a `regtype/1` assertion but it is explicitely qualified. Non-qualified `regtype/1` assertions are assumed the qualifier `check`. Note that checking regular type definitions should be done with the `ciaopp` preprocessor.

Usage: `:- regtype(AssertionStatus,AssertionBody).`

— *The following properties should hold at call time:*

`AssertionStatus` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)

`AssertionBody` is an assertion body. (`assertions_props:assrt_body/1`)

55 Properties which are native to analyzers

Author(s): Francisco Bueno, Manuel Hermenegildo, Pedro Lopez.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#1 (1999/11/29, 17:12:34 MET)

This library contains a set of properties which are natively understood by the different program analyzers of `ciaopp`. They are used by `ciaopp` on output and they can also be used as properties in assertions.

55.1 Usage and interface (`native_props`)

- **Library usage:**

  `:- use_module(library('assertions/native_props'))`

  or also as a package `:- use_package(nativeprops).`

  Note the different names of the library and the package.
- **Exports:**
  - *Properties:*

    `linear/1`, `mshare/1`, `fails/1`, `not_fails/1`, `possibly_fails/1`, `covered/1`, `not_covered/1`, `is_det/1`, `possibly_nondet/1`, `mut_exclusive/1`, `not_mut_exclusive/1`, `size_lb/2`, `size_ub/2`, `steps_lb/2`, `steps_ub/2`, `sideff_pure/1`, `sideff_soft/1`, `sideff_hard/1`.
- **Other modules used:**
  - *System library modules:*

    `andprolog/andprolog_rt`, `terms_vars`, `sort`, `lists`.

55.2 Documentation on exports (`native_props`)

linear/1: PROPERTY

`linear(X)`

`X` is bound to a term which is linear, i.e., if it contains any variables, such variables appear only once in the term. For example, `[1,2,3]` and `f(A,B)` are linear terms, while `f(A,A)` is not.

Usage: `linear(X)`

- *Description:* `X` is instantiated to a linear term.

mshare/1: PROPERTY

`mshare(X)`

`X` contains all *sharing sets* [JL88,MH89] which specify the possible variable occurrences in the terms to which the variables involved in the clause may be bound. Sharing sets are a compact way of representing groundness of variables and dependencies between variables. This representation is however generally difficult to read for humans. For this reason, this information is often translated to `ground/1`, `indep/1` and `indep/2` properties, which are easier to read.

Usage: `mshare(X)`

– *Description:* The sharing pattern is `X`.

fails/1: PROPERTY

`fails(X)`

Calls of the form `X` fail.

Usage: `fails(X)`

– *Description:* Calls of the form `X` fail.

not_fails/1: PROPERTY

`not_fails(X)`

Calls of the form `X` produce at least one solution, or not terminate [DLGH97].

Usage: `not_fails(X)`

– *Description:* All the calls of the form `X` do not fail.

possibly_fails/1: PROPERTY

`possibly_fails(X)`

Non-failure is not ensured for any call of the form `X` [DLGH97]. In other words, nothing can be ensured about non-failure nor termination of such calls.

Usage: `possibly_fails(X)`

– *Description:* Non-failure is not ensured for calls of the form `X`.

covered/1: PROPERTY

`covered(X)`

For any call of the form `X` there is at least one clause whose test succeeds (i.e. all the calls of the form `X` are covered.) [DLGH97].

Usage: `covered(X)`

– *Description:* All the calls of the form `X` are covered.

not_covered/1: PROPERTY

`not_covered(X)`

There is some call of the form `X` for which there is not any clause whose test succeeds [DLGH97].

Usage: `not_covered(X)`

– *Description:* Not all of the calls of the form `X` are covered.

is_det/1: PROPERTY

`is_det(X)`

All calls of the form `X` are deterministic, i.e. produce at most one solution, or not terminate.

Usage: `is_det(X)`

– *Description:* All calls of the form `X` are deterministic.

possibly_nondet/1: PROPERTY

`possibly_nondet(X)`

Non-determinism is not ensured for all calls of the form `X`. In other words, nothing can be ensured about determinacy nor termination of such calls.

Usage: `possibly_nondet(X)`

– *Description:* Non-determinism is not ensured for calls of the form `X`.

mut_exclusive/1: PROPERTY

`mut_exclusive(X)`

For any call of the form `X` at most one clause succeeds, i.e. clauses are pairwise exclusive.

Usage: `mut_exclusive(X)`

– *Description:* For any call of the form `X` at most one clause succeeds.

not_mut_exclusive/1: PROPERTY

`not_mut_exclusive(X)`

Not for all calls of the form `X` at most one clause succeeds. I.e. clauses are not disjoint for some call.

Usage: `not_mut_exclusive(X)`

– *Description:* Not for all calls of the form `X` at most one clause succeeds.

size_lb/2: PROPERTY

`size_lb(X,Y)`

The minimum size of the terms to which the argument `Y` is bound to is given by the expression `Y`. Various measures can be used to determine the size of an argument, e.g., list-length, term-size, term-depth, integer-value, etc. [DL93].

Usage: `size_lb(X,Y)`

– *Description:* `Y` is a lower bound on the size of argument `X`.

size_ub/2: PROPERTY

`size_ub(X,Y)`

The maximum size of the terms to which the argument `Y` is bound to is given by the expression `Y`. Various measures can be used to determine the size of an argument, e.g., list-length, term-size, term-depth, integer-value, etc. [DL93].

Usage: `size_ub(X,Y)`

– *Description:* `Y` is a upper bound on the size of argument `X`.

steps_lb/2: PROPERTY

`steps_lb(X,Y)`

The minimum computation time (in resolution steps) spent by any call of the form `X` is given by the expression `Y` [DLGHL97,LGHD96]

Usage: `steps_lb(X,Y)`

– *Description:* `Y` is a lower bound on the cost of any call of the form `X`.

steps_ub/2: PROPERTY

`steps_ub(X,Y)`

The maximum computation time (in resolution steps) spent by any call of the form `X` is given by the expression `Y` [DL93,LGHD96]

Usage: `steps_ub(X,Y)`

– *Description:* `Y` is a upper bound on the cost of any call of the form `X`.

sideff_pure/1: PROPERTY

Usage: `sideff_pure(X)`

– *Description:* `X` is pure, i.e., has no side-effects.

sideff_soft/1: PROPERTY

Usage: `sideff_soft(X)`

– *Description:* `X` has *soft side-effects*, i.e., those not affecting program execution (e.g., input/output).

sideff_hard/1: PROPERTY

Usage: `sideff_hard(X)`

– *Description:* `X` has *hard side-effects*, i.e., those that might affect program execution (e.g., assert/retract).

indep/1: PREDICATE

Usage: `indep(X)`

– *Description:* The variables in pairs in `X` are pairwise independent.

indep/2: PROPERTY

Usage: `indep(X,Y)`

– *Description:* `X` and `Y` do not have variables in common.

56 Meta-properties

Author(s): Francisco Bueno.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#167 (2002/1/3, 17:43:50 CET)

This library allows the use of some meta-constructs which provide for specifying properties of terms which are unknown at the time of the specification, or expressed with a shorthand for the property definition, i.e., without really defining it.

An example of such use is an assertion which specifies that any property holding upon call will also hold upon exit:

```
:- pred p(X) : Prop(X) => Prop(X).
```

Another example is using shorthands for properties when documenting:

```
:- pred p(X) : regtype(X,(~(list;list);list)).
```

(See below for an explanation of such a regular type.)

56.1 Usage and interface (meta_props)

- **Library usage:**
  `:- use_module(library('assertions/meta_props'))`
  or also as a package `:- use_package(metaprops).`
  Note the different names of the library and the package.
- **Exports:**
  - *Properties:*
    `call/2`, `prop/2`, `regtype/2`.
  - *Multifiles:*
    `callme/2`.

56.2 Documentation on exports (meta_props)

call/2: PROPERTY

`call(P,A)`

`A` has property `P` (provided that `P` is a property). Equivalent to `P(A)`.

Usage: `call(P,A)`

- *Description:* `A` has property `P`.
- *If the following properties hold at call time:*
  `P` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

prop/2: PROPERTY

Usage: `prop(A,P)`

- *Description:* `A` has property `P`.
- *If the following properties hold at call time:*
  `P` has property `^ (callable;prop_abs)`. (`meta_props:prop/2`)

regtype/2: PROPERTY

Usage: `regtype(A,T)`

- *Description:* `A` is of type `T`.
- *If the following properties hold at call time:*
  `T` has property `^ (regtype;prop_abs)`. (`meta_props:prop/2`)

56.3 Documentation on multifiles (meta_props)

callme/2: PREDICATE

(User defined.) A hook predicate you have to define as `callme(P,X):- P(X), !.` in the program that uses this library. This is done automatically if the package is used instead of the library module (but then you *should not* define `callme/2` in your program).

The predicate is *multifile*.

56.4 Documentation on internals (meta_props)

prop_abs/1: PROPERTY

`prop_abs(Prop)`

`Prop` is a *property abstraction*, i.e., a *parametric property*, or a term formed of property abstractions, where the functors used in the term are escaped by `^`.

One particular case of property abstractions are *parametric regular type abstractions*, i.e., a parametric type functor or a `^`-escaped term formed of regular type abstractions.

Such abstractions are a short-hand for a corresponding regular type (correspondingly, property). For example, the following abstraction:

```
^(list;list);list
```

denotes terms of the form `(X;Y)` where `list(X)` and `list(Y)` hold and also terms `T` such that `list(T)` holds. It is equivalent to the regular type:

```
abstract_type((X;Y)):- list(X), list(Y).
abstract_type(T):- list(T).
```

Usage: `prop_abs(Prop)`

- *Description:* `Prop` is a property abstraction.

56.5 Known bugs and planned improvements (meta_props)

- Using a hook predicate is not very elegant. Need something else.
- The cut in the hook prevents backtracking (enough for most uses of properties but not quite ok).

57 ISO-Prolog modes

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.3#112 (1999/11/23, 1:8:50 MET)

This file defines the " modes" used in the documentation of the ISO-Prolog standard. See also Chapter 58 [Classical Prolog modes], page 255 for an alternative set of modes.

57.1 Usage and interface (`isomodes`)

- **Library usage:**
  `:- use_package([assertions,isomodes]).`
- **New operators defined:**
  `?/1` [200,fy], `@/1` [200,fy].
- **New modes defined:**
  `+/1`, `@/1`, `-/1`, `?/1`, `*/1`, `+/2`, `@/2`, `-/2`, `?/2`, `*/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/meta_props`.

57.2 Documentation on new modes (`isomodes`)

+/1: MODE

Usage: `+ A`

- *The following properties are added at call time:*
  `A` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

@/1: MODE

Usage: `@ A`

- *The following properties are added globally:*
  `A` is not further instantiated. (`basic_props:not_further_inst/2`)

-/1: MODE

Usage: `- A`

- *The following properties are added at call time:*
  `A` is a free variable. (`term_typing:var/1`)

?/1: MODE

Unspecified argument.

***/1:** MODE

Unspecified argument.

+/2: MODE

Usage: `A + X`

- *The following properties are added at call time:*
  `A` has property `X`. (`meta_props:call/2`)

@/2: MODE

Usage: `@(A,X)`

- *The following properties are added at call time:*
  `A` has property `X`. (`meta_props:call/2`)
- *The following properties are added upon exit:*
  `A` has property `X`. (`meta_props:call/2`)
- *The following properties are added globally:*
  `A` is not further instantiated. (`basic_props:not_further_inst/2`)

-/2: MODE

Usage: `A - X`

- *The following properties are added at call time:*
  `A` is a free variable. (`term_typing:var/1`)
- *The following properties are added upon exit:*
  `A` has property `X`. (`meta_props:call/2`)

?/2: MODE

Usage: `?(A,X)`

- *Call and exit are compatible with:*
  `A` has property `X`. (`meta_props:call/2`)
- *The following properties are added upon exit:*
  `A` has property `X`. (`meta_props:call/2`)

***/2:** MODE

Usage: `A * X`

- *Call and exit are compatible with:*
  `A` has property `X`. (`meta_props:call/2`)

58 Classical Prolog modes

Author(s): Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 0.8#43 (1999/3/6, 18:39:38 CET)

This file defines a number of very simple " modes" which are frequently useful in programs. These correspond to the modes used in classical Prolog texts with some simple addtions. Note that some of these modes use the same symbol as one of the ISO-modes (see Chapter 57 [ISO-Prolog modes], page 253) but with subtly different meaning.

58.1 Usage and interface (`basicmodes`)

- **Library usage:**
  :- use_package([assertions,basicmodes]).
- **New operators defined:**
  `?/1` [500,fx], `@/1` [500,fx].
- **New modes defined:**
  `+/1`, `-/1`, `?/1`, `@/1`, `in/1`, `out/1`, `go/1`, `+/2`, `-/2`, `?/2`, `@/2`, `in/2`, `out/2`, `go/2`.
- **Other modules used:**
  - *System library modules:*
    `assertions/meta_props`.

58.2 Documentation on new modes (`basicmodes`)

+/1: MODE

Input value in argument.

Usage: `+ A`

- *The following properties are added at call time:*
  `A` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

-/1: MODE

No input value in argument.

Usage: `- A`

- *The following properties are added at call time:*
  `A` is a free variable. (`term_typing:var/1`)

?/1: MODE

Unspecified argument.

@/1: MODE

No output value in argument.

Usage: `@ A`

– *The following properties are added globally:*
`A` is not further instantiated. (`basic_props:not_further_inst/2`)

in/1: MODE

Input argument.

Usage: `in(A)`

– *The following properties are added at call time:*
`A` is currently ground (it contains no variables). (`term_typing:ground/1`)
– *The following properties are added upon exit:*
`A` is currently ground (it contains no variables). (`term_typing:ground/1`)

out/1: MODE

Output argument.

Usage: `out(A)`

– *The following properties are added at call time:*
`A` is a free variable. (`term_typing:var/1`)
– *The following properties are added upon exit:*
`A` is currently ground (it contains no variables). (`term_typing:ground/1`)

go/1: MODE

Ground output (input/output argument).

Usage: `go(A)`

– *The following properties are added upon exit:*
`A` is currently ground (it contains no variables). (`term_typing:ground/1`)

+/2: MODE

Usage: `A + X`

– *Call and exit are compatible with:*
`A` has property `X`. (`meta_props:call/2`)
– *The following properties are added at call time:*
`A` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

-/2: MODE

Usage: `A - X`

– *Call and exit are compatible with:*
`A` has property `X`. (`meta_props:call/2`)
– *The following properties are added at call time:*
`A` is a free variable. (`term_typing:var/1`)

?/2: MODE

Usage: `?(A,X)`

– *Call and exit are compatible with:*

`A` has property `X`. (`meta_props:call/2`)

@/2: MODE

Usage: `@(A,X)`

– *Call and exit are compatible with:*

`A` has property `X`. (`meta_props:call/2`)

– *The following properties are added globally:*

`A` is not further instantiated. (`basic_props:not_further_inst/2`)

in/2: MODE

Usage: `in(A,X)`

– *Call and exit are compatible with:*

`A` has property `X`. (`meta_props:call/2`)

– *The following properties are added at call time:*

`A` is currently ground (it contains no variables). (`term_typing:ground/1`)

– *The following properties are added upon exit:*

`A` is currently ground (it contains no variables). (`term_typing:ground/1`)

out/2: MODE

Usage: `out(A,X)`

– *Call and exit are compatible with:*

`A` has property `X`. (`meta_props:call/2`)

– *The following properties are added at call time:*

`A` is a free variable. (`term_typing:var/1`)

– *The following properties are added upon exit:*

`A` is currently ground (it contains no variables). (`term_typing:ground/1`)

go/2: MODE

Usage: `go(A,X)`

– *Call and exit are compatible with:*

`A` has property `X`. (`meta_props:call/2`)

– *The following properties are added upon exit:*

`A` is currently ground (it contains no variables). (`term_typing:ground/1`)

59 Run-time checking of assertions

Author(s): German Puebla.

This library package allows the use of run-time checks for the assertions introduced in a program.

The recommended way of performing *run-time checks* of predicate assertions in a program is via the Ciao preprocessor (see `ciaopp` manual), which performs the required program transformation. However, this package can also be used to perform checking of program-point assertions.

59.1 Usage and interface (`rtchecks`)

- **Library usage:**

  ```
  :- use_package(rtchecks).
  ```

  or

  ```
  :- module(...,...,[rtchecks]).
  ```

- **Other modules used:**
  - *System library modules:*

    `assertions/meta_props`, `rtchecks/rtchecks_sys`.

59.2 Documentation on internals (`rtchecks`)

check/1: PREDICATE

`check(Property)`

Checks whether the property defined by `Property` holds. Otherwise, a warning message is issued. It corresponds to a program-point check assertion (see Chapter 52 [The Ciao assertion package], page 227).

Usage: `check(Property)`

- *The following properties should hold at call time:*

  `Property` is of type `^ (list;list);list`. (`meta_props:regtype/2`)

59.3 Known bugs and planned improvements (`rtchecks`)

- All the code in this package is included in the user program when it is used, ant there is a lot of it! A module should be used instead.
- `check/1` uses lists instead of "proper" properties.

PART VI - Ciao Prolog library miscellanea

This part documents several Ciao libraries which provide different useful additional functionalities. Such functionalities include performing operating system calls, gathering statistics from the Prolog engine, file and file name manipulation, error and exception handling, fast reading and writing of terms (marshalling and unmarshalling), file locking, program reporting messages, pretty-printing programs and assertions, a browser of the system libraries, additional expansion utilities, concurrent aggregates, graph visualization, etc.

60 Structured stream handling

Version: 0.5#15 (1998/6/9, 16:30:53 MET DST)

60.1 Usage and interface (`streams`)

- **Library usage:**
  `:- use_module(library(streams)).`
- **Exports:**
  - *Predicates:*
    `open_null_stream/1`, `open_input/2`, `close_input/1`, `open_output/2`, `close_output/1`.

60.2 Documentation on exports (`streams`)

open_null_stream/1: PREDICATE

No further documentation available for this predicate.

open_input/2: PREDICATE

No further documentation available for this predicate.

close_input/1: PREDICATE

No further documentation available for this predicate.

open_output/2: PREDICATE

No further documentation available for this predicate.

close_output/1: PREDICATE

No further documentation available for this predicate.

61 Operating system utilities

Author(s): Daniel Cabeza, Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#211 (2002/4/30, 20:40:19 CEST)

This module contains predicates for invoking services which are typically provided by the operating system. Note that the predicates which take names of files or directories as arguments in this module expect atoms, not path aliases. I.e., generally these predicates will not call `absolute_file_name/2` on names of files or directories taken as arguments.

61.1 Usage and interface (system)

- **Library usage:**
  `:- use_module(library(system)).`
- **Exports:**
  - *Predicates:*
    `pause/1`, `time/1`, `datime/1`, `datime/9`, `getenvstr/2`, `setenvstr/2`, `extract_paths/2`, `get_pid/1`, `current_host/1`, `current_executable/1`, `umask/2`, `make_directory/2`, `make_directory/1`, `make_dirpath/2`, `make_dirpath/1`, `working_directory/2`, `cd/1`, `shell/0`, `shell/1`, `shell/2`, `system/1`, `system/2`, `popen/3`, `exec/4`, `exec/3`, `directory_files/2`, `mktemp/2`, `file_exists/1`, `file_exists/2`, `file_property/2`, `file_properties/6`, `modif_time/2`, `modif_time0/2`, `fmode/2`, `chmod/2`, `chmod/3`, `delete_file/1`, `delete_directory/1`, `rename_file/2`, `cyg2win/3`.
  - *Regular Types:*
    `datime_struct/1`, `popen_mode/1`.
  - *Multifiles:*
    `define_flag/3`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

61.2 Documentation on exports (system)

pause/1: PREDICATE

`pause(Seconds)`

Make this thread sleep for some `Seconds`.

time/1: PREDICATE

`time(Time)`

`Time` is unified with the number of seconds elapsed since January, 1, 1970 (UTC).

datime/1: PREDICATE

`datime(Datime)`

`Datime` is unified with a term of the form `datime(Year,Month,Day,Hour,Minute,Second)` which contains the current date and time.

datime/9: PREDICATE

`datime(Time,Year,Month,Day,Hour,Min,Sec,WeekDay,YearDay)`

`Time` is as in `time/1`. `WeekDay` is the number of days since Sunday, in the range 0 to 6. `YearDay` is the number of days since January 1, in the range 0 to 365.

Usage 1: `datime(+int,?int,?int,?int,?int,?int,?int,?int,?int)`

– *Description:* If `Time` is given, the rest of the arguments are unified with the date and time to which the `Time` argument refers.

Usage 2: `datime(-int,?int,?int,?int,?int,?int,?int,?int,?int)`

– *Description:* Bound `Time` to current time and the rest of the arguments refer to current time.

datime_struct/1: REGTYPE

A regular type, defined as follows:

```
datime_struct(datime(Year,Month,Day,Hour,Min,Sec)) :-
        int(Year),
        int(Month),
        int(Day),
        int(Hour),
        int(Min),
        int(Sec).
```

getenvstr/2: PREDICATE

`getenvstr(Name,Value)`

The environment variable `Name` has `Value`. Fails if variable `Name` is not defined.

setenvstr/2: PREDICATE

`setenvstr(Name,Value)`

The environment variable `Name` is assigned `Value`.

extract_paths/2: PREDICATE

`extract_paths(String,Paths)`

Interpret `String` as the value of a UNIX environment variable holding a list of paths and return in `Paths` the list of the paths. Paths in `String` are separated by colons, and an empty path is considered a shorthand for '.' (current path). The most typical environment variable with this format is PATH. For example, this is a typical use:

```
?- set_prolog_flag(write_strings, on).

yes
?- getenvstr('PATH', PATH), extract_paths(PATH, Paths).

PATH = ":/home/bardo/bin:/home/clip/bin:/opt/bin/:/bin",
Paths = [".","/home/bardo/bin","/home/clip/bin","/opt/bin/","/bin"] ?

yes
?-
```

get_pid/1: PREDICATE

`get_pid(Pid)`

Unifies `Pid` with the process identificator of the current process or thread.

current_host/1: PREDICATE

`current_host(Hostname)`

`Hostname` is unified with the fully qualified name of the host.

current_executable/1: PREDICATE

`current_executable(Path)`

Unifies `Path` with the path to the current executable.

umask/2: PREDICATE

`umask(OldMask,NewMask)`

The process file creation mask was `OldMask`, and it is changed to `NewMask`.

Usage 2: `umask(OldMask,NewMask)`

- *Description:* Gets the process file creation mask without changing it.
- *The following properties should hold at call time:*

  `OldMask` is a free variable. (`term_typing:var/1`)

  `NewMask` is a free variable. (`term_typing:var/1`)

  The terms `OldMask` and `NewMask` are strictly identical. (`term_compare:== /2`)
- *The following properties hold upon exit:*

  `OldMask` is an integer. (`basic_props:int/1`)

  `NewMask` is an integer. (`basic_props:int/1`)

make_directory/2: PREDICATE

`make_directory(DirName,Mode)`

Creates the directory `DirName` with a given `Mode`. This is, as usual, operated against the current umask value.

make_directory/1: PREDICATE

`make_directory(DirName)`

Equivalent to `make_directory(D,0o777)`.

make_dirpath/2: PREDICATE

`make_dirpath(Path,Mode)`

Creates the whole `Path` for a given directory with a given `Mode`. As an example, `make_dirpath('/tmp/var/mydir/otherdir')`.

make_dirpath/1: PREDICATE

`make_dirpath(Path)`

Equivalent to `make_dirpath(D,0o777)`.

working_directory/2: PREDICATE

`working_directory(OldDir,NewDir)`

Unifies current working directory with `OldDir`, and then changes the working directory to `NewDir`. Calling `working_directory(Dir,Dir)` simply unifies `Dir` with the current working directory without changing anything else.

Usage 2: `working_directory(OldDir,NewDir)`

- *Description:* Gets current working directory.
- *The following properties should hold at call time:*

  `OldDir` is a free variable. (`term_typing:var/1`)

  `NewDir` is a free variable. (`term_typing:var/1`)

  The terms `OldDir` and `NewDir` are strictly identical. (`term_compare:== /2`)
- *The following properties hold upon exit:*

  `OldDir` is an atom. (`basic_props:atm/1`)

  `NewDir` is an atom. (`basic_props:atm/1`)

cd/1: PREDICATE

`cd(Path)`

Changes working directory to `Path`.

shell/0: PREDICATE

Usage:

- *Description:* Execs the shell specified by the environment variable `SHELL`. When the shell process terminates, control is returned to Prolog.

shell/1: PREDICATE

`shell(Command)`

`Command` is executed in the shell specified by the environment variable `SHELL`. It succeeds if the exit code is zero and fails otherwise.

shell/2: PREDICATE

`shell(Command,ReturnCode)`

Executes `Command` in the shell specified by the environment variable `SHELL` and stores the exit code in `ReturnCode`.

system/1: PREDICATE

`system(Command)`

Executes `Command` using the shell `/bin/sh`.

system/2: PREDICATE

`system(Command,ReturnCode)`

Executes `Command` in the `/bin/sh` shell and stores the exit code in `ReturnCode`.

popen/3: PREDICATE

`popen(Command,Mode,Stream)`

Open a pipe to process `Command` in a new shell with a given `Mode` and return a communication `Stream` (as in UNIX `popen(3)`). If `Mode` is `read` the output from the process is sent to `Stream`. If `Mode` is `write`, `Stream` is sent as input to the process. `Stream` may be read from or written into using the ordinary stream I/O predicates. `Stream` must be closed explicitly using `close/1`, i.e., it is not closed automatically when the process dies.

popen_mode/1: REGTYPE

Usage: `popen_mode(M)`

– *Description:* `M` is 'read' or 'write'.

exec/4: PREDICATE

`exec(Command,StdIn,StdOut,StdErr)`

Starts the process `Command` and returns the standart I/O streams of the process in `StdIn`, `StdOut`, and `StdErr`.

exec/3: PREDICATE

`exec(Command,StdIn,StdOut)`

Starts the process `Command` and returns the standart I/O streams of the process in `StdIn` and `StdOut`. `Standard error` is connected to whichever the parent process had it connected to.

directory_files/2: PREDICATE

`directory_files(Directory,FileList)`

`FileList` is the unordered list of entries (files, directories, etc.) in `Directory`.

mktemp/2: PREDICATE

`mktemp(Template,Filename)`

Returns a unique `Filename` based on `Template`: `Template` must be a valid file name with six trailing X, which are substituted to create a new file name.

file_exists/1: PREDICATE

`file_exists(File)`

Succeeds if `File` (a file or directory) exists (and is accessible).

file_exists/2: PREDICATE

`file_exists(File,Mode)`

`File` (a file or directory) exists and it is accessible with `Mode`, as in the Unix call `access(2)`. Typically, `Mode` is 4 for read permission, 2 for write permission and 1 for execute permission.

file_property/2: PREDICATE

`file_property(File,Property)`

`File` has the property `Property`. The possible properties are:

type(`Type`)
: `Type` is one of `regular`, `directory`, `symlink`, `fifo`, `socket` or `unknown`.

linkto(`Linkto`)
: If `File` is a symbolic link, `Linkto` is the file pointed to by the link (and the other properties come from that file, not from the link itself).

mod_time(`ModTime`)
: `ModTime` is the time of last modification (seconds since January, 1, 1970).

mode(`Protection`)
: `Protection` is the protection mode.

size(`Size`) `Size` is the size.

If `Property` is uninstantiated, the predicate will enumerate the properties on backtracking.

file_properties/6: PREDICATE

`file_properties(Path,Type,Linkto,Time,Protection,Size)`

The file `Path` has the following properties:

- File type `Type` (one of `regular`, `directory`, `symlink`, `fifo`, `socket` or `unknown`).
- If `Path` is a symbolic link, `Linkto` is the file pointed to. All other properties come from the file pointed, not the link. `Linkto` is '' if `Path` is not a symbolic link.
- Time of last modification `Time` (seconds since January, 1, 1970).
- Protection mode `Protection`.
- Size in bytes `Size`.

modif_time/2: PREDICATE

`modif_time(File,Time)`

The file `File` was last modified at `Time`, which is in seconds since January, 1, 1970. Fails if `File` does not exist.

modif_time0/2: PREDICATE

`modif_time0(File,Time)`

If `File` exists, `Time` is its latest modification time, as in `modif_time/2`. Otherwise, if `File` does not exist, `Time` is zero.

fmode/2: PREDICATE

`fmode(File,Mode)`

The file `File` has protection mode `Mode`.

chmod/2: PREDICATE

`chmod(File,NewMode)`

Change the protection mode of file `File` to `NewMode`.

chmod/3: PREDICATE

`chmod(File,OldMode,NewMode)`

The file `File` has protection mode `OldMode` and it is changed to `NewMode`.

Usage 2: `chmod(File,OldMode,NewMode)`

- *Description:* Equivalent to fmode(`File`,`OldMode`)
- *The following properties should hold at call time:*

  `File` is an atom. (`basic_props:atm/1`)

  `OldMode` is a free variable. (`term_typing:var/1`)

  `NewMode` is a free variable. (`term_typing:var/1`)

  The terms `OldMode` and `NewMode` are strictly identical. (`term_compare:== /2`)
- *The following properties hold upon exit:*

  `File` is an atom. (`basic_props:atm/1`)

  `OldMode` is an atom. (`basic_props:atm/1`)

  `NewMode` is an atom. (`basic_props:atm/1`)

delete_file/1: PREDICATE

`delete_file(File)`

Delete the file `File`.

delete_directory/1: PREDICATE

`delete_directory(File)`

Delete the directory `Directory`.

rename_file/2: PREDICATE

`rename_file(File1,File2)`

Change the name of `File1` to `File2`.

cyg2win/3: PREDICATE

`cyg2win(+CygWinPath,?WindowsPath,+SpawSlash)`

Converts a path in the CygWin style to a Windows-style path, rewriting the driver part. If `SwapSlash` is `swap`, slashes are converted in to backslash. If it is `noswap`, they are preserved.

61.3 Documentation on multifiles (`system`)

define_flag/3: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

62 Prolog system internal predicates

Author(s): Manuel Carro, Daniel Cabeza, Mats Carlsson.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#153 (2000/5/29, 10:24:35 CEST)

This module implements some miscellaneous predicates which provide access to some internal statistics, special properties of the predicates, etc.

62.1 Usage and interface (prolog_sys)

- **Library usage:**
  `:- use_module(library(prolog_sys)).`
- **Exports:**
  - *Predicates:*
    `statistics/0`, `statistics/2`, `predicate_property/2`, `current_atom/1`, `garbage_collect/0`, `new_atom/1`.

62.2 Documentation on exports (prolog_sys)

statistics/0: PREDICATE

Usage:

- *Description:* Prints statistics about the system.

statistics/2: PREDICATE

Usage 1: `statistics(Time_option,Time_result)`

- *Description:* Gather information about time (either process time or wall time) since last consult or since start of program. Results are returned in milliseconds.
- *The following properties should hold at call time:*
  Options to get information about execution time. `Time_option` must be one of `runtime`, `walltime`. (`prolog_sys:time_option/1`)
  `Time_result` is any term. (`basic_props:term/1`)
- *The following properties hold upon exit:*
  Options to get information about execution time. `Time_option` must be one of `runtime`, `walltime`. (`prolog_sys:time_option/1`)
  `Time_result` is a two-element list of integers. The first integer is the time since the start of the execution; the second integer is the time since the previous consult to time. (`prolog_sys:time_result/1`)

Usage 2: `statistics(Memory_option,Memory_result)`

- *Description:* Gather information about memory consumption.
- *The following properties should hold at call time:*
  Options to get information about memory usage. (`prolog_sys:memory_option/1`)
  `Memory_result` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

Options to get information about memory usage. (`prolog_sys:memory_option/1`)

Result is a two-element list of integers. The first element is the space taken up by the option selected, measured in bytes; the second integer is zero for program space (which grows as necessary), and the amount of free space otherwise. (`prolog_sys:memory_result/1`)

Usage 3: `statistics(Garbage_collection_option,Gc_result)`

– *Description:* Gather information about garbage collection.

– *The following properties should hold at call time:*

Options to get information about garbage collection. (`prolog_sys:garbage_collection_option/1`)

`Gc_result` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

Options to get information about garbage collection. (`prolog_sys:garbage_collection_option/1`)

`Gc_result` is a tree-element list of integers, related to garbage collection and memory management. When `stack_shifts` is selected, the first one is the number of shifts (reallocations) of the local stack; the second is the number of shifts of the trail, and the third is the time spent in these shifts. When `garbage_collection` is selected, the numbers are, respectively, the number of garbage collections performed, the number of bytes freed, and the time spent in garbage collection. (`prolog_sys:gc_result/1`)

Usage 4: `statistics(Symbol_option,Symbol_result)`

– *Description:* Gather information about number of symbols and predicates.

– *The following properties should hold at call time:*

Option to get information about the number of symbols in the program. (`prolog_sys:symbol_option/1`)

`Symbol_result` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

Option to get information about the number of symbols in the program. (`prolog_sys:symbol_option/1`)

`Symbol_result` is a two-element list of integers. The first one is the number of atom, functor, and predicate names in the symbol table. The second is the number of predicates known to be defined (although maybe without clauses). (`prolog_sys:symbol_result/1`)

Usage 5: `statistics(Option,?term)`

– *Description:* If `Option` is unbound, it is bound to the values on the other cases.

predicate_property/2: PREDICATE

Usage: `predicate_property(Head,Property)`

– *Description:* The predicate with clause `Head` is `Property`.

– *The following properties should hold at call time:*

`Head` is any term. (`basic_props:term/1`)

`Property` is any term. (`basic_props:term/1`)

– *The following properties hold upon exit:*

`Head` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Property` is an atom. (`basic_props:atm/1`)

current_atom/1: PREDICATE

Usage: `current_atom(Atom)`

- *Description:* Enumerates on backtracking all the existing atoms in the system.
- *The following properties should hold at call time:*

  `Atom` is a free variable. (`term_typing:var/1`)
- *The following properties hold upon exit:*

  `Atom` is an atom. (`basic_props:atm/1`)

garbage_collect/0: PREDICATE

Usage:

- *Description:* Forces garbage collection when called.

new_atom/1: PREDICATE

Usage: `new_atom(Atom)`

- *Description:* Returns, on success, a new atom, not existing before in the system. The entry argument must be a variable. The idea behind this atom generation is to provide a fast source of identifiers for new objects, concurrent predicates, etc. on the fly.
- *The following properties should hold at call time:*

  `Atom` is a free variable. (`term_typing:var/1`)
- *The following properties hold upon exit:*

  `Atom` is an atom. (`basic_props:atm/1`)

62.3 Documentation on internals (`prolog_sys`)

time_option/1: REGTYPE

Usage: `time_option(M)`

- *Description:* Options to get information about execution time. `M` must be one of `runtime`, `walltime`.

memory_option/1: REGTYPE

Usage: `memory_option(M)`

- *Description:* Options to get information about memory usage.

garbage_collection_option/1: REGTYPE

Usage: `garbage_collection_option(M)`

- *Description:* Options to get information about garbage collection.

symbol_option/1: REGTYPE

Usage: `symbol_option(M)`

- *Description:* Option to get information about the number of symbols in the program.

time_result/1: REGTYPE

Usage: `time_result(Result)`

- *Description:* `Result` is a two-element list of integers. The first integer is the time since the start of the execution; the second integer is the time since the previous consult to time.

memory_result/1: REGTYPE

Usage: `memory_result(Result)`

- *Description:* Result is a two-element list of integers. The first element is the space taken up by the option selected, measured in bytes; the second integer is zero for program space (which grows as necessary), and the amount of free space otherwise.

gc_result/1: REGTYPE

Usage: `gc_result(Result)`

- *Description:* `Result` is a tree-element list of integers, related to garbage collection and memory management. When `stack_shifts` is selected, the first one is the number of shifts (reallocations) of the local stack; the second is the number of shifts of the trail, and the third is the time spent in these shifts. When `garbage_collection` is selected, the numbers are, respectively, the number of garbage collections performed, the number of bytes freed, and the time spent in garbage collection.

symbol_result/1: REGTYPE

Usage: `symbol_result(Result)`

- *Description:* `Result` is a two-element list of integers. The first one is the number of atom, functor, and predicate names in the symbol table. The second is the number of predicates known to be defined (although maybe without clauses).

62.4 Known bugs and planned improvements (`prolog_sys`)

- The space used by the process is not measured here: process data, code, and stack also take up memory. The memory reported for atoms is not what is actually used, but the space used up by the hash table (which is enlarged as needed).

63 Atom to term conversion

Author(s): Francisco Bueno, Daniel Cabeza.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#189 (2002/2/14, 17:16:46 CET)

63.1 Usage and interface (atom2term)

- **Library usage:**
  `:- use_module(library(atom2term)).`
- **Exports:**
  - *Predicates:*
    `atom2term/2`, `string2term/2`, `parse_term/3`.

63.2 Documentation on exports (atom2term)

atom2term/2: PREDICATE

Usage: `atom2term(+Atom,-Term)`

- *Description:* Convert an atom into a term. `Atom` is an atom, but must have term syntax. `Term` is a term resulting from parsing `Atom` char by char.

string2term/2: PREDICATE

Usage: `string2term(+String,-Term)`

- *Description:* Same as `atom2term/2` but first argument is a string (containing a term).

parse_term/3: PREDICATE

Usage: `parse_term(+String,-Term,?Dummy)`

- *Description:* `String` is parsed into `Term` upto `Dummy` (which is the non-parsed rest of the list).

63.3 Known bugs and planned improvements (atom2term)

- This is just a quick hack written mainly for parsing daVinci's messages. There should be a call to the standard reader to do this!

64 ctrlcclean (library)

Version: 0.4#5 (1998/2/24)

64.1 Usage and interface (ctrlcclean)

- **Library usage:**
  `:- use_module(library(ctrlcclean)).`
- **Exports:**
  - *Predicates:*
    `ctrlc_clean/1`, `delete_on_ctrlc/2`, `ctrlcclean/0`.
- **Other modules used:**
  - *System library modules:*
    `system`.

64.2 Documentation on exports (ctrlcclean)

ctrlc_clean/1: PREDICATE

No further documentation available for this predicate.

Meta-predicate with arguments: `ctrlc_clean(goal)`.

delete_on_ctrlc/2: PREDICATE

No further documentation available for this predicate.

ctrlcclean/0: PREDICATE

No further documentation available for this predicate.

65 errhandle (library)

Version: 0.4#5 (1998/2/24)

65.1 Usage and interface (errhandle)

- **Library usage:**
  `:- use_module(library(errhandle)).`
- **Exports:**
  - *Predicates:*
    `error_protect/1`, `handle_error/2`.

65.2 Documentation on exports (errhandle)

error_protect/1: PREDICATE

No further documentation available for this predicate.

Meta-predicate with arguments: `error_protect(goal)`.

handle_error/2: PREDICATE

No further documentation available for this predicate.

66 Fast reading and writing of terms

Author(s): Daniel Cabeza, Oscar Portela Arjona.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#16 (2000/8/29, 13:44:18 CEST)

This library provides predicates to support reading / writing of terms on a format designed to be handled on read faster than standard representation.

66.1 Usage and interface (`fastrw`)

- **Library usage:**
  `:- use_module(library(fastrw)).`
- **Exports:**
  - *Predicates:*
    `fast_read/1`, `fast_write/1`, `fast_read/2`, `fast_write/2`, `fast_write_to_string/3`.
- **Other modules used:**
  - *System library modules:*
    `dict`.

66.2 Documentation on exports (`fastrw`)

fast_read/1: PREDICATE

`fast_read(Term)`

The next term is read from current standard input and is unified with `Term`. The syntax of the term must agree with fast_read / fast_write format. If the end of the input has been reached, `Term` is unified with the term 'end_of_file'. Further calls to `fast_read/1` will then cause an error.

fast_write/1: PREDICATE

`fast_write(Term)`

Output `Term` in a way that `fast_read/1` and `fast_read/2` will be able to read it back.

fast_read/2: PREDICATE

`fast_read(Stream,Term)`

The next term is read from `Stream` and unified with `Term`. The syntax of the term must agree with fast_read / fast_write format. If the end of the input has been reached, `Term` is unified with the term 'end_of_file'. Further calls to `fast_read/2` will then cause an error.

fast_write/2: PREDICATE

`fast_write(Stream,Term)`

Output `Term` to `Stream` in a way that `fast_read/1` and `fast_read/2` will be able to read it back.

fast_write_to_string/3: PREDICATE

No further documentation available for this predicate.

66.3 Known bugs and planned improvements (`fastrw`)

- Both `fast_read/2` and `fast_write/2` simply set the current output/input and call `fast_read/1` and `fast_write/1`. Therefore, in the event an error hapens during its execution, the current input / output streams may be left pointing to the `Stream`

67 File name manipulation

Author(s): Daniel Cabeza, Angel Fernandez Pineda.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.3#51 (1999/9/9, 16:28:44 MEST)
This library provides some small utilities to handle file name syntax.

67.1 Usage and interface (`filenames`)

- **Library usage:**
  `:- use_module(library(filenames)).`
- **Exports:**
  - *Predicates:*
    `no_path_file_name/2`, `file_name_extension/3`, `basename/2`, `extension/2`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

67.2 Documentation on exports (`filenames`)

no_path_file_name/2: PREDICATE

This predicate will extract the last item (usually the file name) from a given path.

The first argument must be instantiated to a string or atom. Whenever the first argument is an atom, the second argument will be an atom. Whenever the first argument is a string, the second argument will be a string.

This predicate will fail under any of the following conditions:

- First argument is not an atom, nor a string.
- Second argument is not the last given path item (given path is the first argument).

Those are the most usual usages of no_path_file_name/2:

```
?- no_path_file_name_("/home/nexusV/somefile.txt",K).

K = "somefile.txt" ?

yes
?- no_path_file_name('/home/nexusV/somefile.txt',K).

K = 'somefile.txt' ?

yes
?-
```

Usage: `no_path_file_name(Path,FileName)`

- *Description:* `FileName` is the file corresponding to the given `Path`.
- *Call and exit should be compatible with:*
  `Path` is an atom or a string (`filenames:atom_or_str/1`)
  `FileName` is an atom or a string (`filenames:atom_or_str/1`)

file_name_extension/3: PREDICATE

This predicate may be used in two ways:

- To create a file name from its components: name and extension. For instance:

```
?- file_name_extension(File,mywork,'.txt').

File = 'mywork.txt' ?

yes
?-
```

- To split a file name into its name and extension. For Instance:

```
?- file_name_extension('mywork.txt',A,B).

A = mywork,
B = '.txt' ?

yes
?-
```

Any other usage of file_name_extension/3 will cause the predicate to fail. Notice that valid arguments are accepted both as atoms or strings.

Usage: `file_name_extension(FileName,BaseName,Extension)`

– *Description:* Splits a `FileName` into its `BaseName` and `Extension`.

– *Call and exit should be compatible with:*

`FileName` is an atom or a string	(`filenames:atom_or_str/1`)
`BaseName` is an atom or a string	(`filenames:atom_or_str/1`)
`Extension` is an atom or a string	(`filenames:atom_or_str/1`)

basename/2: PREDICATE

`basename(FileName,BaseName)`

`BaseName` is `FileName` without extension. Equivalent to `file_name_extension(FileName,BaseName,_)`. Useful to extract the base name of a file using functional syntax.

Usage:

– *Calls should, and exit will be compatible with:*

`FileName` is an atom or a string	(`filenames:atom_or_str/1`)
`BaseName` is an atom or a string	(`filenames:atom_or_str/1`)

extension/2: PREDICATE

`extension(FileName,Extension)`

`Extension` is the extension (suffix) of `FileName`. Equivalent to `file_name_extension(FileName,_,Extension)`. Useful to extract the extension of a file using functional syntax.

Usage:

– *Calls should, and exit will be compatible with:*

`FileName` is an atom or a string	(`filenames:atom_or_str/1`)
`Extension` is an atom or a string	(`filenames:atom_or_str/1`)

68 File I/O utilities

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.5#55 (2000/2/11, 21:19:43 CET)

68.1 Usage and interface (`file_utils`)

- **Library usage:**
  `:- use_module(library(file_utils)).`
- **Exports:**
  - *Predicates:*
    `file_terms/2`, `copy_stdout/1`, `file_to_string/2`, `stream_to_string/2`.
- **Other modules used:**
  - *System library modules:*
    `read`, `streams`.

68.2 Documentation on exports (`file_utils`)

file_terms/2: PREDICATE

Usage 1: `file_terms(@File,?Terms)`

- *Description:* Transform a file `File` to/from a list of terms `Terms`.
- *The following properties should hold upon exit:*
  `@File` is a source name. (`streams_basic:sourcename/1`)
  `?Terms` is a list. (`basic_props:list/1`)

Usage 2: `file_terms(File,Terms)`

- *Description:* Unifies `Terms` with the list of all terms in `File`.
- *The following properties should hold at call time:*
  `File` is a source name. (`streams_basic:sourcename/1`)
  `Terms` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*
  `File` is a source name. (`streams_basic:sourcename/1`)
  `Terms` is a list. (`basic_props:list/1`)

Usage 3: `file_terms(File,Terms)`

- *Description:* Writes the terms in list `Terms` (including the ending '.') onto file `File`.
- *The following properties should hold at call time:*
  `File` is a source name. (`streams_basic:sourcename/1`)
  `Terms` is a list. (`basic_props:list/1`)
- *The following properties should hold upon exit:*
  `File` is a source name. (`streams_basic:sourcename/1`)
  `Terms` is a list. (`basic_props:list/1`)

copy_stdout/1: PREDICATE

Usage: `copy_stdout(+File)`

- *Description:* Copies file `File` to standard output.
- *The following properties should hold upon exit:*

  `+File` is a source name. (`streams_basic:sourcename/1`)

file_to_string/2: PREDICATE

Usage: `file_to_string(+FileName,-String)`

- *Description:* Reads all the characters from the file `FileName` and returns them in `String`.
- *Call and exit should be compatible with:*

  `+FileName` is a source name. (`streams_basic:sourcename/1`)

  `-String` is a string (a list of character codes). (`basic_props:string/1`)

stream_to_string/2: PREDICATE

Usage: `stream_to_string(+Stream,-String)`

- *Description:* Reads all the characters from `Stream` and returns them in `String`.
- *Call and exit should be compatible with:*

  `+Stream` is an open stream. (`streams_basic:stream/1`)

  `-String` is a string (a list of character codes). (`basic_props:string/1`)

69 File locks

Author(s): J. Gomez, D. Cabeza, M. Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#159 (2001/11/27, 11:58:24 CET)

This module implements file locks: the ability to lock a fiel so that other processes cannot access it until the file is unlocked. **It is, however, not working.** The predicates do nothing. Proper implementation is planned for a near future.

69.1 Usage and interface (`file_locks`)

- **Library usage:**
  `:- use_module(library(file_locks)).`
- **Exports:**
  - *Predicates:*
    `lock_file/3`, `unlock_file/2`.

69.2 Documentation on exports (`file_locks`)

lock_file/3: PREDICATE

Usage: `lock_file(File,LockType,Result)`

- *Description:* Tries to lock `File` with `LockType` and returns the result (either `true` or `false`) in `Result`.
- *The following properties should hold at call time:*

  `File` is an atom. (`basic_props:atm/1`)

  `LockType` is an atom. (`basic_props:atm/1`)

  `Result` is an atom. (`basic_props:atm/1`)

unlock_file/2: PREDICATE

Usage: `unlock_file(File,Result)`

- *Description:* Tries to unlock `File` the result (either `true` or `false`) in `Result`.
- *The following properties should hold at call time:*

  `File` is an atom. (`basic_props:atm/1`)

  `Result` is an atom. (`basic_props:atm/1`)

69.3 Known bugs and planned improvements (`file_locks`)

- No doing anything helpful.

70 Term manipulation utilities

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#141 (2001/11/12, 17:47:36 CET)

70.1 Usage and interface (terms)

- **Library usage:**
  `:- use_module(library(terms)).`
- **Exports:**
  - *Predicates:*
    `copy_args/3`, `arg/2`, `atom_concat/2`.

70.2 Documentation on exports (terms)

copy_args/3: PREDICATE

Usage: `copy_args(N,Term,Copy)`

- *Description:* `Term` and `Copy` have the same first `N` arguments.
- *The following properties should hold at call time:*
  `N` is a non-negative integer. (`basic_props:nnegint/1`)

arg/2: PREDICATE

Usage: `arg(Term,Arg)`

- *Description:* `Arg` is an argument of `Term`. Gives each of the arguments on backtracking.

atom_concat/2: PREDICATE

`atom_concat(Atms,Atm)`

`Atm` is the atom resulting from concatenating all atoms in the list `Atms` in the order in which they appear.

71 Term checking utilities

Version: 1.7#143 (2001/11/12, 17:51:0 CET)

71.1 Usage and interface (terms_check)

- **Library usage:**
  `:- use_module(library(terms_check)).`
- **Exports:**
  - *Predicates:*
    `ask/2`, `instance/2`, `variant/2`.

71.2 Documentation on exports (terms_check)

ask/2: PREDICATE

`ask(Term1,Term2)`

`Term1` and `Term2` unify without producing bindings for the variables of `Term1`. I.e., `instance(Term1,Term2)` holds.

instance/2: PREDICATE

`instance(Term1,Term2)`

`Term1` is an instance of `Term2`.

variant/2: PREDICATE

`variant(Term1,Term2)`

`Term1` and `Term2` are identical up to renaming.

71.3 Other information (terms_check)

Currently, `ask/2` and `instance/2` are exactly the same. However, `ask/2` is more general, since it is also applicable to constraint domains (although not yet implemented): for the particular case of Herbrand terms, it is just `instance/2` (which is the only ask check currently implemented).

72 Term variables sets

Version: 1.7#142 (2001/11/12, 17:49:44 CET)

72.1 Usage and interface (terms_vars)

- **Library usage:**
  `:- use_module(library(terms_vars)).`
- **Exports:**
  - *Predicates:*
    `varset/2`, `varsbag/3`, `varset_in_args/2`.
- **Other modules used:**
  - *System library modules:*
    `idlists`, `sort`.

72.2 Documentation on exports (terms_vars)

varset/2: PREDICATE

`varset(Term,Xs)`

`Xs` is the sorted list of all the variables in `Term`.

varsbag/3: PREDICATE

`varsbag(Term,Vs,Xs)`

`Vs` is the list of all the variables in `Term` ordered as they appear in `Term` left-to-right depth-first (including duplicates) plus `Xs`.

varset_in_args/2: PREDICATE

Usage: `varset_in_args(T,LL)`

- *Description:* Each list of `LL` contains the variables of an argument of `T`, for each argument, and in left to right order.
- *The following properties should hold at call time:*
  `T` is currently a term which is not a free variable. (`term_typing:nonvar/1`)
- *The following properties should hold upon exit:*
  `LL` is a list of `list(var)`s. (`basic_props:list/2`)

73 Printing status and error messages

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.3#108 (1999/11/18, 13:48:3 MET)
This is a very simple library for printing status and error messages to the console.

73.1 Usage and interface (messages)

- **Library usage:**
  `:- use_module(library(messages)).`
- **Exports:**
  - *Predicates:*
    `error_message/1`, `error_message/2`, `error_message/3`, `warning_message/1`, `warning_message/2`, `warning_message/3`, `note_message/1`, `note_message/2`, `note_message/3`, `simple_message/1`, `simple_message/2`, `optional_message/2`, `optional_message/3`, `debug_message/1`, `debug_message/2`, `debug_goal/2`, `debug_goal/3`.
  - *Multifiles:*
    `callme/2`, `issue_debug_messages/1`.
- **Other modules used:**
  - *System library modules:*
    `assertions/meta_props`, `format`, `lists`, `filenames`.

73.2 Documentation on exports (messages)

error_message/1: PREDICATE

Meta-predicate with arguments: `error_message(addmodule)`.

Usage: `error_message(Text)`

- *Description:* The text provided in `Text` is printed as an ERROR message.
- *The following properties should hold at call time:*
  `Text` is a string (a list of character codes). (`basic_props:string/1`)

error_message/2: PREDICATE

Meta-predicate with arguments: `error_message(?,addmodule)`.

Usage: `error_message(Text,ArgList)`

- *Description:* The text provided in `Text` is printed as an ERROR message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`.
- *The following properties should hold at call time:*
  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)
  `ArgList` is a list. (`basic_props:list/1`)

error_message/3: PREDICATE

Meta-predicate with arguments: `error_message(?,?,addmodule)`.

Usage: `error_message(Lc,Text,ArgList)`

- *Description:* The text provided in `Text` is printed as an ERROR message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`, and reporting error location `Lc` (file and line numbers).
- *The following properties should hold at call time:*

  `Lc` is of type `^loc(atm,int,int)`. (`meta_props:regtype/2`)

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

warning_message/1: PREDICATE

Meta-predicate with arguments: `warning_message(addmodule)`.

Usage: `warning_message(Text)`

- *Description:* The text provided in `Text` is printed as a WARNING message.
- *The following properties should hold at call time:*

  `Text` is a string (a list of character codes). (`basic_props:string/1`)

warning_message/2: PREDICATE

Meta-predicate with arguments: `warning_message(?,addmodule)`.

Usage: `warning_message(Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a WARNING message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

warning_message/3: PREDICATE

Meta-predicate with arguments: `warning_message(?,?,addmodule)`.

Usage: `warning_message(Lc,Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a WARNING message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`, and reporting error location `Lc` (file and line numbers).
- *The following properties should hold at call time:*

  `Lc` is of type `^loc(atm,int,int)`. (`meta_props:regtype/2`)

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

note_message/1: PREDICATE

Meta-predicate with arguments: `note_message(addmodule)`.

Usage: `note_message(Text)`

- *Description:* The text provided in `Text` is printed as a NOTE.
- *The following properties should hold at call time:*

  `Text` is a string (a list of character codes). (`basic_props:string/1`)

note_message/2: PREDICATE

Meta-predicate with arguments: `note_message(?,addmodule)`.

Usage: `note_message(Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a NOTE, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

note_message/3: PREDICATE

Meta-predicate with arguments: `note_message(?,?,addmodule)`.

Usage: `note_message(Lc,Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a NOTE, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`, and reporting error location `Lc` (file and line numbers).
- *The following properties should hold at call time:*

  `Lc` is of type `^loc(atm,int,int)`. (`meta_props:regtype/2`)

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

simple_message/1: PREDICATE

Usage: `simple_message(Text)`

- *Description:* The text provided in `Text` is printed.
- *The following properties should hold at call time:*

  `Text` is a string (a list of character codes). (`basic_props:string/1`)

simple_message/2: PREDICATE

Usage: `simple_message(Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a message, using the arguments in `ArgList`.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

optional_message/2: PREDICATE

Usage: `optional_message(Text,Opts)`

- *Description:* The text provided in `Text` is printed as a message, but only if the atom `-v` is a member of `Opts`. These predicates are meant to be used for optional messages, which are only to be printed when *verbose* output is requested explicitly.
- *The following properties should hold at call time:*

  `Text` is a string (a list of character codes). (`basic_props:string/1`)

  `Opts` is a list of `atm`s. (`basic_props:list/2`)

optional_message/3: PREDICATE

Usage: `optional_message(Text,ArgList,Opts)`

- *Description:* The text provided in `Text` is printed as a message, using the arguments in `ArgList`, but only if the atom `-v` is a member of `Opts`. These predicates are meant to be used for optional messages, which are only to be printed when *verbose* output is requested explicitly.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

  `Opts` is a list of `atm`s. (`basic_props:list/2`)

debug_message/1: PREDICATE

Meta-predicate with arguments: `debug_message(addmodule)`.

Usage: `debug_message(Text)`

- *Description:* The text provided in `Text` is printed as a debugging message. These messages are turned `on` by defining a fact of `issue_debug_messages/1` with the module name as argument.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

debug_message/2: PREDICATE

Meta-predicate with arguments: `debug_message(?,addmodule)`.

Usage: `debug_message(Text,ArgList)`

- *Description:* The text provided in `Text` is printed as a debugging message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`. These messages are turned `on` by defining a fact of `issue_debug_messages/1` which the module name as argument.
- *The following properties should hold at call time:*

  `Text` is an atom or string describing how the arguments should be formatted. If it is an atom it will be converted into a string with `name/2`. (`format:format_control/1`)

  `ArgList` is a list. (`basic_props:list/1`)

debug_goal/2: PREDICATE

Meta-predicate with arguments: `debug_goal(goal,addmodule)`.

Usage: `debug_goal(Goal,Text)`

– *Description:* `Goal` is called. The text provided in `Text` is then printed as a debugging message. The whole process (including running `Goal`) is turned `on` by defining a fact of `issue_debug_messages/1` with the module name as argument.

debug_goal/3: PREDICATE

Meta-predicate with arguments: `debug_goal(goal,?,addmodule)`.

Usage: `debug_goal(Goal,Text,ArgList)`

– *Description:* `Goal` is called. The text provided in `Text` is then printed as a debugging message, using the arguments in `ArgList` to interpret any variable-related formatting commands embedded in `Text`. Note that the variables in `ArgList` can be computed by `Goal`. The whole process (including running `Goal`) is turned `on` by defining a fact of `issue_debug_messages/1` with the module name as argument.

73.3 Documentation on multifiles (messages)

callme/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

issue_debug_messages/1: PREDICATE

The predicate is *multifile*.

The predicate is of type *data*.

Usage: `issue_debug_messages(Module)`

– *Description:* Printing of debugging messages is enabled for module `Module`.

– *The following properties should hold upon exit:*

`Module` is currently instantiated to an atom. (`term_typing:atom/1`)

73.4 Known bugs and planned improvements (messages)

- Debug message switching should really be done with an expansion, for performance.

74 A simple pretty-printer for Ciao programs

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#112 (2001/6/25, 17:34:9 CEST)
This library module writes out to standard output a clause or a list of clauses.

74.1 Usage and interface (pretty_print)

- **Library usage:**
  `:- use_module(library(pretty_print)).`
- **Exports:**
  - *Predicates:*
    `pretty_print/2`, `pretty_print/3`.
- **Other modules used:**
  - *System library modules:*
    `vndict`, `write`.

74.2 Documentation on exports (pretty_print)

pretty_print/2: PREDICATE

Usage: `pretty_print(Cls,Flags)`

- *Description:* Prints each clause in the list `Cls` after numbering its variables.
- *The following properties should hold at call time:*
  `pretty_print:clauses(Cls)` (`pretty_print:clauses/1`)
  `Flags` is a list of `flags`. (`basic_props:list/2`)

pretty_print/3: PREDICATE

Usage: `pretty_print(Cls,Flags,Ds)`

- *Description:* Prints each clause in the list `Cls` after using the corresponding variable names dictionary in `Ds` to name its variables.
- *The following properties should hold at call time:*
  `pretty_print:clauses(Cls)` (`pretty_print:clauses/1`)
  `Flags` is a list of `flags`. (`basic_props:list/2`)
  `Ds` is a dictionary of variable names. (`vndict:varnamedict/1`)

74.3 Documentation on internals (pretty_print)

clauses/1: REGTYPE

A regular type, defined as follows:

```
clauses([]).
clauses([_1|_2]) :-
        clause(_1),
        clauses(_2).
clauses(_1) :-
        clause(_1).
```

clause/1: REGTYPE

A regular type, defined as follows:

```
clause(_1) :-
        clterm(_1).
clause((_1,_2)) :-
        clterm(_1),
        term(_2).
```

clterm/1: REGTYPE

A regular type, defined as follows:

```
clterm(clause(_1,_2)) :-
        callable(_1),
        body(_2).
clterm(directive(_1)) :-
        body(_1).
clterm((_1:-_2)) :-
        callable(_1),
        body(_2).
clterm(_1) :-
        callable(_1).
```

body/1: REGTYPE

A well formed body, including cge expressions and &-concurrent expressions. The atomic goals may or may not have a key in the form `^(goal:any)`, and may or may not be module qualified, but if they are it has to be in the form `^(^(moddesc:goal):any)`.

Usage: `body(X)`

- *Description:* `X` is a printable body.

flag/1: REGTYPE

A keyword `ask/1` flags whether to output *asks* or *whens* and `nl/1` whether to separate clauses with a blank line or not.

Usage: `flag(X)`

- *Description:* `X` is a flag for the pretty-printer.

75 Pretty-printing assertions

Author(s): Francisco Bueno Carrillo.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.5#2 (1999/11/29, 18:2:53 MET)

This module defines some predicates which are useful for writing assertions in a readable form.

75.1 Usage and interface (assrt_write)

- **Library usage:**
  `:- use_module(library(assrt_write)).`
- **Exports:**
  - *Predicates:*
    `write_assertion/6`, `write_assertion_as_comment/6`.
- **Other modules used:**
  - *System library modules:*
    `format`, `assertions/assrt_lib`, `messages`, `assertions/assertions_props`.

75.2 Documentation on exports (assrt_write)

write_assertion/6: PREDICATE

Usage: `write_assertion(Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to current output.
- *Call and exit should be compatible with:*
  `Status` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)
  `Type` is an admissible kind of assertion. (`assertions_props:assrt_type/1`)
  `Body` is a normalized assertion body. (`assertions_props:nabody/1`)
  `Dict` is a dictionary of variable names. (`assertions_props:dictionary/1`)
  `Flag` is `status` or `nostatus`. (`assrt_write:status_flag/1`)

write_assertion_as_comment/6: PREDICATE

Usage: `write_assertion_as_comment(Goal,Status,Type,Body,Dict,Flag)`

- *Description:* Writes the (normalized) assertion to current output as a Prolog comment.
- *Call and exit should be compatible with:*
  `Status` is an acceptable status for an assertion. (`assertions_props:assrt_status/1`)
  `Type` is an admissible kind of assertion. (`assertions_props:assrt_type/1`)
  `Body` is a normalized assertion body. (`assertions_props:nabody/1`)
  `Dict` is a dictionary of variable names. (`assertions_props:dictionary/1`)
  `Flag` is `status` or `nostatus`. (`assrt_write:status_flag/1`)

76 The Ciao library browser

Author(s): Angel Fernandez Pineda.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#21 (2000/9/26, 13:37:17 CEST)

`librowser` library provides a set of predicates wich enables the user to interactively find Ciao/Prolog libraries and/or any predicate exported by them.

This is a simple example:

```
?- apropos('*find*').
persdbrt_sql: dbfindall/4
persdbrtsql: dbfindall/4
conc_aggregates: findall/3
linda: rd_findall/3
vndict: find_name/4
internals: $find_file/8
aggregates: findall/4,findall/3

yes
?-
```

Librowser is specially usefull when using inside GNU Emacs, just place the cursor over a librowser response and press C-cTAB in order to get help on the related predicate. Refer to the **"Using Ciao inside GNU Emacs"** chapter for further information.

76.1 Usage and interface (`librowser`)

- **Library usage:**

  It is not necesary to use this library at user programs. It was designed to be used at the Ciao *toplevel* shell: `ciaosh`. In order to do so, just make use of `use_module/1` as follows:

  ```
  use_module(library(librowser)).
  ```

  Then, the library interface must be read. This is automatically done when calling any predicate at librowser, and the entire process will take a little moment.So, you should want to perform such a process after loading the Ciao toplevel:

  ```
  Ciao 0.9 #75: Fri Apr 30 19:04:24 MEST 1999
  ?- use_module(library(librowser)).

  yes
  ?- update.
  ```

  Whether you want this process to be automatically performed when loading `ciaosh`, you may include those lines in your *.ciaorc* personal initialization file.

- **Exports:**
  - *Predicates:*

    `update/0`, `browse/2`, `where/1`, `describe/1`, `system_lib/1`, `apropos/1`.
- **Other modules used:**
  - *System library modules:*

    `filenames`, `read`, `fastrw`, `system`, `streams`, `patterns`, `lists`.

76.2 Documentation on exports (`librowser`)

update/0: PREDICATE

This predicate will scan the Ciao system libraries for predicate definitions. This may be done once time before calling any other predicate at this library.

update/0 will also be automatically called (once) when calling any other predicate at librowser.

Usage:

– *Description:* Creates an internal database of modules at Ciao system libraries.

browse/2: PREDICATE

This predicate is fully reversible, and is provided to inspect concrete predicate specifications. For example:

```
?- browse(M,findall/A).

A = 3,
M = conc_aggregates ? ;

A = 4,
M = aggregates ? ;

A = 3,
M = aggregates ? ;

no
?-
```

Usage: `browse(Module,Spec)`

– *Description:* Asocciates the given `Spec` predicate specification with the `Module` which exports it.

– *The following properties should hold at call time:*

`Module` is a module name (an atom) (`librowser:module_name/1`)

`Spec` is a **Functor/Arity** predicate specification (`librowser:pred_spec/1`)

where/1: PREDICATE

This predicate will print at the screen the module needed in order to import a given predicate specification. For example:

```
?- where(findall/A).
findall/3 exported at module conc_aggregates
findall/4 exported at module aggregates
findall/3 exported at module aggregates

yes
?-
```

Usage: `where(Spec)`

– *Description:* Display what module to load in order to import the given `Spec`.

– *The following properties should hold at call time:*

`Spec` is a **Functor/Arity** predicate specification (`librowser:pred_spec/1`)

describe/1: PREDICATE

This one is used to find out which predicates were exported by a given module. Very usefull when you know the library, but not the concrete predicate. For example:

```
?- describe(librowser).
Predicates at library librowser :

apropos/1
system_lib/1
describe/1
where/1
browse/2
update/0

yes
?-
```

Usage: `describe(Module)`

- *Description:* Display a list of exported predicates at the given `Module`
- *The following properties should hold at call time:*

  `Module` is a module name (an atom) (`librowser:module_name/1`)

system_lib/1: PREDICATE

It retrieves on backtracking all Ciao system libraries stored in the internal database. Certainly, those which were scanned at `update/0` calling.

Usage: `system_lib(Module)`

- *Description:* `Module` variable will be successively instantiated to the system libaries stored in the internal database.
- *The following properties should hold at call time:*

  `Module` is a module name (an atom) (`librowser:module_name/1`)

apropos/1: PREDICATE

This tool makes use of regular expresions in order to find predicate specifications. It is very usefull whether you can't remember the full name of a predicate. Regular expresions take the same format as described in library `patterns`. Example:

```
?- apropos('atom_*').

terms: atom_concat/2
concurrency: atom_lock_state/2
atomic_basic: atom_concat/3,atom_length/2,atom_codes/2
iso_byte_char: atom_chars/2

yes
?-
```

Usage: `apropos(RegSpec)`

- *Description:* This will search any predicate specification `Spec` which matches the given `RegSpec` incomplete predicate specification.
- *The following properties should hold at call time:*

  `RegSpec` is a Pattern/Arity specification. (`librowser:apropos_spec/1`)

76.3 Documentation on internals (`librowser`)

apropos_spec/1: REGTYPE

Defined as:

```
apropos_spec(_1).
apropos_spec(Pattern/Arity) :-
        pattern(Pattern),
        int(Arity).
```

Usage: `apropos_spec(S)`

– *Description:* `S` is a Pattern/Arity specification.

77 Code translation utilities

Author(s): Angel Fernandez Pineda.

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This library offers a general way to perform clause body expansions. Goal, fact and spec translation predicates are authomatically called when needed, while this utility navigates through the meta-argument specification of the body itself. All predicates within this library must be called at *second-pass expansions*, since it uses information stored at `c_itf` library.

77.1 Usage and interface (`expansion_tools`)

- **Library usage:**
  This library is provided as a tool for those modules which performs source-to-source code translation, usually known as *code expanders*. It may be loaded as other modules using a `use_module/1`. Nothing special needs to be done.
- **Exports:**
  - *Predicates:*
    `imports_meta_pred/3`, `body_expander/6`, `arg_expander/6`.
- **Other modules used:**
  - *System library modules:*
    `compiler/c_itf`.

77.2 Documentation on exports (`expansion_tools`)

imports_meta_pred/3: PREDICATE

Macro provided in order to know meta-predicate specifications accessible from a module.

Usage: `imports_meta_pred(Module,MetaSpec,AccessibleAt)`

- *Description:* Tells whether `MetaSpec` meta-predicate specification is accessible from `Module`. `AccessibleAt` will be binded to '-' whether meta-predicate is a builtin one. If not, it will be unified with the module which defines the meta-predicate.
- *The following properties should hold at call time:*

`Module` is an atom.	(`basic_props:atm/1`)
`MetaSpec` is any term.	(`basic_props:term/1`)
`AccessibleAt` is a free variable.	(`term_typing:var/1`)

body_expander/6: PREDICATE

This predicate is the main translation tool. It navigates through a clause body, when a single *goal* appears, user-code is called in order to perform a translation. Whether user-code fails to translate the involved goal, it remains the same. Regardless that goal is translated or not, an argument expansion will be performed over all goals if applicable (see `arg_expander/6` predicate).

Variable (unknown at compile time) goals will also be attempt to translate.

Meta-predicate with arguments: `body_expander(pred(3),pred(3),pred(3),?,?,?).`

Usage:

`body_expander(GoalTrans,FactTrans,SpecTrans,Module,Body,ExpandedBody)`

- *Description:* Translates `Body` to `ExpandedBody` by the usage of user-defined translators `GoalTrans`, `FactTrans` and `SpecTrans`. The module where the original body appears must be unified with `Module` argument.
- *The following properties should hold at call time:*

  `GoalTrans` is a user-defined predicate which performs *goal* meta-type translation (`expansion_tools:goal_expander/1`)

  `FactTrans` is a user-defined predicate which performs *fact* meta-type translation (`expansion_tools:fact_expander/1`)

  `SpecTrans` is a user-defined predicate which performs *spec* meta-type translation (`expansion_tools:spec_expander/1`)

  `Module` is an atom. (`basic_props:atm/1`)

  `Body` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

  `ExpandedBody` is a free variable. (`term_typing:var/1`)

arg_expander/6: PREDICATE

This predicate is an auxiliary translation tool, which is used by `body_expander/6` predicate. It remains exported as a macro. The predicate navigates through the *meta-argument specification* of a goal. Whether a *goal,fact or spec* argument appears, user-code is called in order to perform a translation. Whether user-code fails to translate the involved argument, it remains the same. Builtins as ','/2 or ';'/2 are treated as meta-predicates defining *goal* meta-arguments. When a *goal* meta-argument is located, `body_expander/6` will be called in order to navigate through it. Notice that a *goal* meta-argument may be unified with another goal defining another meta-argument, so navigation is required. If arguments are not known to arg_expander/6, translation will not occur. This is posible whether goal or qualifing module are variables.

Meta-predicate with arguments: `arg_expander(pred(3),pred(3),pred(3),?,?,?).`

Usage:

`arg_expander(GoalTrans,FactTrans,SpecTrans,Module,Goal,ExpandedGoal)`

- *Description:* Translates `Goal` to `ExpandedGoal` by applying user-defined translators (`GoalTrans`, `FactTrans` and `SpecTrans`) to each meta-argument present at such goal. The module where the original goal appears must be unified with `Module` argument.
- *The following properties should hold at call time:*

  `GoalTrans` is a user-defined predicate which performs *goal* meta-type translation (`expansion_tools:goal_expander/1`)

  `FactTrans` is a user-defined predicate which performs *fact* meta-type translation (`expansion_tools:fact_expander/1`)

  `SpecTrans` is a user-defined predicate which performs *spec* meta-type translation (`expansion_tools:spec_expander/1`)

  `Module` is an atom. (`basic_props:atm/1`)

  `Goal` is currently a term which is not a free variable. (`term_typing:nonvar/1`)

  `ExpandedBody` is a free variable. (`term_typing:var/1`)

77.3 Documentation on internals (expansion_tools)

expander_pred/1: PROPERTY

Usage: `expander_pred(Pred)`

- *Description:* `Pred` is a user-defined predicate used to perform code translations. First argument will be binded to the corresponding term to be translated. Second argument must be binded to the corresponding translation. Third argument will be binded to the current module were first argument appears. Additional arguments will be user-defined.

77.4 Known bugs and planned improvements (expansion_tools)

- *pred(N)* meta-arguments are not supported at this moment.

78 Low-level concurrency/multithreading primitives

Author(s): Manuel Carro.

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This module provides basic mechanisms for using concurrency and implementing multi-goal applications. It provides a means for arbitrary goals to be specified to be run in a separate stack set; in that case, they are assigned a goal identifier with which further accesses (e.g., asking for more solutions) to the goal can be made. Additionally, in some architectures, these goals can be assigned an O.S. thread, separate from the one which made the initial call, thus providing concurrency and, in multiprocessors, parallelism capabilities.

As for now, the memory space of the threads (c.f., stack sets) is separate in the sense that goals are copied to the new stack set, and bindings of variables are not seen among stack sets which allows forward and backward execution to proceed independently in each stack set, at the cost of the initial goal copy. However, the program space (including, specially, the concurrent predicates) are shared and seen by all the goals and threads, and should be used as the primary means of communication and synchronization. Higer level libraries can be built using these basic blocks.

Additionally, a small set of lock primitives are provided. Locks are associated with atom names. Whereas the concurrent database facilities are enough to implement locks, semaphores, messages, etc., the predicates implementing atom-based locks are faster than the ones accessing the concurrent database (but they are less powerful).

78.1 Usage and interface (concurrency)

- **Library usage:**

  `:- use_module(library(concurrency)).`
- **Exports:**
  - *Predicates:*

    `eng_call/4`, `eng_call/3`, `eng_backtrack/2`, `eng_cut/1`, `eng_release/1`, `eng_wait/1`, `eng_kill/1`, `eng_killothers/0`, `eng_self/1`, `goal_id/1`, `eng_goal_id/1`, `eng_status/0`, `lock_atom/1`, `unlock_atom/1`, `atom_lock_state/2`, `concurrent/1`.
- **Other modules used:**
  - *System library modules:*

    `prolog_sys`.

78.2 Documentation on exports (concurrency)

eng_call/4: PREDICATE

Meta-predicate with arguments: `eng_call(goal,?,?,?)`.

Usage: `eng_call(+Goal,+EngineCreation,+ThreadCreation,-GoalId)`

- *Description:* Calls `Goal` in a new engine (stack set), possibly using a new thread, and returns a `GoalId` to designate this new goal henceforth. `EngineCreation` can be either `wait` or `create`; the distinction is not yet meaningful. `ThreadCreation` can be one of `self`, `wait`, or `create`. In the first case the creating thread is used

to execute `Goal`, and thus it has to wait until its first result or failure. The call will fail if `Goal` fails, and succeed otherwise. However, the call will always suceed when a remote thread is started. The space and identifiers reclaimed for the thread must be explicitly deallocated by calling `eng_release/1`. `GoalId`s are unique in each execution of a Ciao Prolog program.

– *The following properties should hold at call time:*

`+Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`+EngineCreation` is an atom. (`basic_props:atm/1`)

`+ThreadCreation` is an atom. (`basic_props:atm/1`)

`-GoalId` is an integer. (`basic_props:int/1`)

eng_call/3: PREDICATE

Meta-predicate with arguments: `eng_call(goal,?,?)`.

Usage: `eng_call(+Goal,+EngineCreation,+ThreadCreation)`

– *Description:* Similar to `eng_call/4`, but the thread (if created) and stack areas are automatically released upon success or failure of the goal. No `GoalId` is provided for further interaction with the goal.

– *The following properties should hold at call time:*

`+Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`+EngineCreation` is an atom. (`basic_props:atm/1`)

`+ThreadCreation` is an atom. (`basic_props:atm/1`)

eng_backtrack/2: PREDICATE

Usage: `eng_backtrack(+GoalId,+ThreadCreation)`

– *Description:* Performs backtracking on the goal designed by `GoalId`. A new thread can be used to perform backtracking, according to `ThreadCreation` (same as in `eng_call/4`). Fails if the goal is backtracked over by the local thread, and there are no more solutions. Always succeeds if executed by a remote thread. The engine is **not** automatically released up upon failure: `eng_release/1` must be called to that end.

– *The following properties should hold at call time:*

`+GoalId` is an integer. (`basic_props:int/1`)

`+ThreadCreation` is an atom. (`basic_props:atm/1`)

eng_cut/1: PREDICATE

Usage: `eng_cut(+GoalId)`

– *Description:* Performs a *cut* in the execution of the goal `GoalId`. The next call to `eng_backtrack/2` will therefore backtrack all the way and fail.

– *The following properties should hold at call time:*

`+GoalId` is an integer. (`basic_props:int/1`)

eng_release/1: PREDICATE

Usage: `eng_release(+GoalId)`

- *Description:* Cleans up and releases the engine executing the goal designed by `GoalId`. The engine must be idle, i.e., currently not exedcuting any goal. `eng_wait/1` can be used to ensure this.
- *The following properties should hold at call time:*

  `+GoalId` is an integer. (`basic_props:int/1`)

eng_wait/1: PREDICATE

Usage: `eng_wait(+GoalId)`

- *Description:* Waits for the engine executing the goal denoted by `GoalId` to finish the computation (i.e., it has finished searching for a solution, either with success or failure).
- *The following properties should hold at call time:*

  `+GoalId` is an integer. (`basic_props:int/1`)

eng_kill/1: PREDICATE

Usage: `eng_kill(+GoalId)`

- *Description:* Kills the thread executing `GoalId` (if any), and frees the memory used up by the stack set. Usually one should wait (`eng_wait/1`) for a goal, and then release it, but killing the thread explicitly allows recovering from error states. A goal cannot kill itself. This feature should be used with caution, because there are situations where killing a thread might render the system in an unstable state. Threads should cooperate in their killing, but if the killed thread is blocked in a I/O operation, or inside an internal critical region, this cooperation is not possible and the system, although stopped, might very well end up in a incosistent state.
- *The following properties should hold at call time:*

  `+GoalId` is an integer. (`basic_props:int/1`)

eng_killothers/0: PREDICATE

Usage:

- *Description:* Kills threads and releases stack sets of all active goals, but the one calling `eng_killothers`. Again, a safety measure. The same cautions as with `eng_kill/1` should be taken.

eng_self/1: PREDICATE

Usage: `eng_self(?GoalId)`

- *Description:* `GoalId` is unified with the identifier of the goal within which `eng_self/1` is executed. `eng_self/1` is deprecated, and eng_goal_id/1 should be used instead.
- *The following properties should hold at call time:*

  `?GoalId` is an integer. (`basic_props:int/1`)

goal_id/1: PREDICATE

Usage: `goal_id(?GoalId)`

- *Description:* `GoalId` is unified with the identifier of the goal within which `goal_id/1` is executed. `goal_id/1` is deprecated, and eng_goal_id/1 should be used instead.
- *The following properties should hold at call time:*

  `?GoalId` is an integer. (`basic_props:int/1`)

eng_goal_id/1: PREDICATE

Usage: `eng_goal_id(?GoalId)`

- *Description:* `GoalId` is unified with the identifier of the goal within which `eng_goal_id/1` is executed.
- *The following properties should hold at call time:*

  `?GoalId` is an integer. (`basic_props:int/1`)

eng_status/0: PREDICATE

Usage:

- *Description:* Prints to standard output the current status of the stack sets.

lock_atom/1: PREDICATE

Usage: `lock_atom(+Atom)`

- *Description:* The semaphore associated to `Atom` is accessed; if its value is nonzero, it is atomically decremented and the execution of this thread proceeds. Otherwise, the goal waits until a nonzero value is reached. The semaphore is then atomically decremented and the execution of this thread proceeds.
- *The following properties should hold at call time:*

  `+Atom` is an atom. (`basic_props:atm/1`)

unlock_atom/1: PREDICATE

Usage: `unlock_atom(+Atom)`

- *Description:* The semaphore associated to `Atom` is atomically incremented.
- *The following properties should hold at call time:*

  `+Atom` is an atom. (`basic_props:atm/1`)

atom_lock_state/2: PREDICATE

Usage 1: `atom_lock_state(+Atom,+Value)`

- *Description:* Sets the semaphore associated to `Atom` to `Value`. This is usually done at the beginning of the execution, but can be executed at any time. If not called, semaphore associated to atoms are by default inited to 1. It should be used with caution: arbitrary use can transform programs using locks in a mess of internal relations. The change of a semaphore value in a place other than the initialization stage of a program is **not** among the allowed operations as defined by Dijkstra [Dij65,BA82].

– *The following properties should hold at call time:*

`+Atom` is an atom. (`basic_props:atm/1`)

`+Value` is an integer. (`basic_props:int/1`)

Usage 2: `atom_lock_state(+Atom,-Value)`

– *Description:* Consults the `Value` of the semaphore associated to `Atom`. Use sparingly and mainly as a medium to check state correctness. Not among the operations on semaphore by Djikstra.

– *The following properties should hold at call time:*

`+Atom` is an atom. (`basic_props:atm/1`)

`-Value` is an integer. (`basic_props:int/1`)

concurrent/1: PREDICATE

`concurrent F/A`

The predicate named `F` with arity `A` is made concurrent in the current module at runtime (useful for predicate names generated on-the-fly). This difficults a better compile-time analysis, but in turn offers more flexibility to applications. It is also faster for some applications: if several agents have to share data in a stuctured fashion (e.g., the generator knows and wants to restrict the data generated to a set of other threads), a possibility is to use the same concurrent fact and emply a field within the fact to distinguish the receiver/sender. This can cause many threads to access and wait on the same fact, which in turns can create contention problems. It is much better to create a new concurrent fact and to use that new name as a channel to communicate the different threads.
`concurrent/1` can either be given a predicate spec in the form `Name/Arity`, with `Name` and `Arity` bound, or to give a value only to `Arity`, and let the system choose a new, unused `Name` for the fact.

78.3 Known bugs and planned improvements (`concurrency`)

- Available only for Windows 32 environments and for architectures implementing POSIX threads.
- Some implementation of threads have a limit on the total number of threads that can be created by a process. Thread creation, in this case, just hangs. A better solution is planned for the future.
- Creating many concurrent facts may fill up the atom table, causing Ciao Prolog to abort.

79 All solutions concurrent predicates

Author(s): Concurrent-safe (and incomplete) version of the aggregates predicates, based on the regular versions by Richard A. O'Keefe and David H.D. Warren. Concurrency-safeness provided by Manuel Carro..

This module implements thread-safe aggregation predicates. Its use and results should be the same as those in the aggregates library, but several goals can use them concurrently without the interference and wrong results (due to implementation reasons) aggregates might lead to. This particular implementation is completely based on the one used in the aggregates library.

79.1 Usage and interface (conc_aggregates)

- **Library usage:**
  `:- use_module(library(conc_aggregates)).`
- **Exports:**
  - *Predicates:*
    `findall/3`.
- **Other modules used:**
  - *System library modules:*
    `prolog_sys`.

79.2 Documentation on exports (conc_aggregates)

findall/3: PREDICATE

Meta-predicate with arguments: `findall(?,goal,?)`.

Usage: `findall(?Template,+Generator,?List)` ⟨• ISO •⟩

- *Description:* A special case of bagof, where all free variables in the `Generator` are taken to be existentially quantified. Safe in concurrent applications.
- *The following properties should hold upon exit:*
  `Template` is any term. (`basic_props:term/1`)
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)
  `Set` is a list. (`basic_props:list/1`)

79.3 Known bugs and planned improvements (conc_aggregates)

- Thread-safe `setof/3` is not yet implemented.
- Thread-safe `bagof/3` is not yet implemented.

80 The socket interface

Author(s): Manuel Carro, Daniel Cabeza.

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Version of last change: 1.7#58 (2001/2/8, 11:46:41 CET)

This module defines primitives to open sockets, send, and receive data from them. This allows communicating with other processes, on the same machine or across the Internet. The reader should also consult standard bibliography on the topic for a proper use of these primitives.

80.1 Usage and interface (sockets)

- **Library usage:**
  `:- use_module(library(sockets)).`
- **Exports:**
  - *Predicates:*
    `connect_to_socket/3`, `socket_recv/2`, `hostname_address/2`, `socket_shutdown/2`, `socket_recv_code/3`, `socket_send/2`, `select_socket/5`, `socket_accept/2`, `bind_socket/3`, `connect_to_socket_type/4`.
  - *Regular Types:*
    `socket_type/1`, `shutdown_type/1`.
- **Other modules used:**
  - *System library modules:*
    `sockets/sockets_c`.

80.2 Documentation on exports (sockets)

connect_to_socket/3: PREDICATE

Usage: `connect_to_socket(+Host,+Port,-Stream)`

- *Description:* Calls `connect_to_socket_type/4` with SOCK_STREAM connection type. This is the connection type you want in order to use the `write/2` and `read/2` predicates (and other stream IO related predicates).
- *Call and exit should be compatible with:*

`+Host` is an atom. (`basic_props:atm/1`)

`+Port` is an integer. (`basic_props:int/1`)

`-Stream` is an open stream. (`streams_basic:stream/1`)

socket_recv/2: PREDICATE

Usage: `socket_recv(+Stream,?String)`

- *Description:* As `socket_recv_code/3`, but the return code is ignored.
- *Call and exit should be compatible with:*

`+Stream` is an open stream. (`streams_basic:stream/1`)

`?String` is a string (a list of character codes). (`basic_props:string/1`)

socket_type/1: REGTYPE

Defines the atoms which can be used to specify the socket type recognized by `connect_to_socket_type/4`. Defined as follows:

```
socket_type(stream).
socket_type(dgram).
socket_type(raw).
socket_type(seqpacket).
socket_type(rdm).
```

Usage: `socket_type(T)`

- *Description:* `T` is a valid socket type.

shutdown_type/1: REGTYPE

Usage: `shutdown_type(T)`

- *Description:* `T` is a valid shutdown type.

hostname_address/2: PREDICATE

Usage: `hostname_address(+Hostname,?Address)`

- *Description:* `Address` is unified with the atom representing the address (in AF_INET format) corresponding to `Hostname`.
- *Call and exit should be compatible with:*

`+Hostname` is an atom.	(`basic_props:atm/1`)
`?Address` is an atom.	(`basic_props:atm/1`)

socket_shutdown/2: PREDICATE

Usage: `socket_shutdown(+Stream,+How)`

- *Description:* Shut down a duplex communication socket with which `Stream` is associated. All or part of the communication can be shutdown, depending on the value of `How`. The atoms `read`, `write`, or `read_write` should be used to denote the type of closing required.
- *Call and exit should be compatible with:*

`+Stream` is an open stream.	(`streams_basic:stream/1`)
`+How` is a valid shutdown type.	(`sockets:shutdown_type/1`)

socket_recv_code/3: PREDICATE

Usage: `socket_recv_code(+Stream,?String,?Length)`

- *Description:* Receives a `String` from the socket associated to `Stream`, and returns its `Length`. If `Length` is -1, no more data is available.
- *Call and exit should be compatible with:*

`+Stream` is an open stream.	(`streams_basic:stream/1`)
`?String` is a string (a list of character codes).	(`basic_props:string/1`)
`?Length` is an integer.	(`basic_props:int/1`)

socket_send/2: PREDICATE

Usage: `socket_send(+Stream,+String)`

- *Description:* Sends `String` to the socket associated to `Stream`. The socket has to be in connected state. `String` is not supposed to be NULL terminated, since it is a Prolog string. If a NULL terminated string is needed at the other side, it has to be explicitly created in Prolog.
- *Call and exit should be compatible with:*

  `+Stream` is an open stream. (`streams_basic:stream/1`)

  `+String` is a string (a list of character codes). (`basic_props:string/1`)

select_socket/5: PREDICATE

Usage: `select_socket(+Socket,-NewStream,+TO_ms,+Streams,-ReadStreams)`

- *Description:* Wait for data available in a list of `Streams` and in a `Socket`. `Streams` is a list of Prolog streams which will be tested for reading. `Socket` is a socket (i.e., an integer denoting the O.S. port number) or a free variable. `TO_ms` is a number denoting a timeout. Within this timeout the `Streams` and the `Socket` are checked for the availability of data to be read. `ReadStreams` is the list of streams belonging to `Streams` which have data pending to be read. If `Socket` was a free variable, it is ignored, and `NewStream` is not checked. If `Socket` was instantiated to a port number and there are connections pending, a connection is accepted and connected with the Prolog stream in `NewStream`.
- *Call and exit should be compatible with:*

  `+Socket` is an integer. (`basic_props:int/1`)

  `-NewStream` is an open stream. (`streams_basic:stream/1`)

  `+TO_ms` is an integer. (`basic_props:int/1`)

  `+Streams` is a list of `streams`. (`basic_props:list/2`)

  `-ReadStreams` is a list of `streams`. (`basic_props:list/2`)

socket_accept/2: PREDICATE

Usage: `socket_accept(+Sock,-Stream)`

- *Description:* Creates a new `Stream` connected to `Sock`.
- *Call and exit should be compatible with:*

  `+Sock` is an integer. (`basic_props:int/1`)

  `-Stream` is an open stream. (`streams_basic:stream/1`)

bind_socket/3: PREDICATE

Usage: `bind_socket(?Port,+Length,-Socket)`

- *Description:* Returs an AF_INET `Socket` bound to `Port` (which may be assigned by the OS or defined by the caller), and listens to it (hence no listen call in this set of primitives). `Length` specifies the maximum number of pending connections.
- *Call and exit should be compatible with:*

  `?Port` is an integer. (`basic_props:int/1`)

  `+Length` is an integer. (`basic_props:int/1`)

  `-Socket` is an integer. (`basic_props:int/1`)

connect_to_socket_type/4: PREDICATE

Usage: `connect_to_socket_type(+Host,+Port,+Type,-Stream)`

- *Description:* Returns a `Stream` which connects to `Host`. The `Type` of connection can be defined. A `Stream` is returned, which can be used to `write/2` to, to `read/2`, to `socket_send/2` to, or to `socket_recv/2` from the socket.
- *Call and exit should be compatible with:*

`+Host` is currently instantiated to an atom.	(`term_typing:atom/1`)
`+Port` is an integer.	(`basic_props:int/1`)
`+Type` is a valid socket type.	(`sockets:socket_type/1`)
`-Stream` is an open stream.	(`streams_basic:stream/1`)

PART VII - Ciao Prolog extensions

The libraries documented in this part extend the Ciao language in several different ways. The extensions include:

- pure Prolog programming (well, this can be viewed more as a restriction than an extension);
- feature terms or *records* (i.e., structures with names for each field);
- parallel programming (e.g., &-Prolog style);
- functional syntax;
- higher-order library;
- global variables;
- `setarg` and `undo`;
- delaying predicate execution;
- active modules;
- breadth-first execution;
- iterative deepening-based execution;
- constraint logic programming;
- object oriented programming.

81 Pure Prolog package

This library package allows the use of *pure Prolog* in a Ciao module/program. It is based on the fact that if an *engine module* is imported explicitly then all of them have to be imported explicitly. The engine modules are:

- `engine(arithmetic)`
  Chapter 20 [Arithmetic], page 113.
- `engine(atomic_basic)`
  Chapter 19 [Basic predicates handling names of constants], page 109.
- `engine(attributes)`
  Chapter 28 [Attributed variables], page 153.
- `engine(basic_props)`
  Chapter 15 [Basic data types and properties], page 93.
- `engine(basiccontrol)`
  Chapter 13 [Control constructs/predicates], page 87.
- `engine(data_facts)`
  Chapter 25 [Fast/concurrent update of facts], page 139.
- `engine(exceptions)`
  Chapter 23 [Exception handling], page 131.
- `engine(io_aux)`
  Chapter 27 [Message printing primitives], page 149.
- `engine(io_basic)`
  Chapter 22 [Basic input/output], page 125.
- `engine(prolog_flags)`
  Chapter 24 [Changing system behaviour and various flags], page 133.
- `engine(streams_basic)`
  Chapter 21 [Basic file/stream handling], page 117.
- `engine(system_info)`
  Chapter 29 [Gathering some basic internal info], page 157.
- `engine(term_basic)`
  Chapter 17 [Basic term manipulation], page 103.
- `engine(term_compare)`
  Chapter 18 [Comparing terms], page 105.
- `engine(term_typing)`
  Chapter 16 [Extra-logical properties for typing], page 99.

Note that if any of these modules is explicitely imported in a program then the language defaults to Pure Prolog, plus the functionality added by the modules explicitely imported.

It is recommended that if you explicitely import an engine module you also use this package, which will guarantee that the predicate `true/0` is defined (note that this is the only Ciao builtin which cannot be redefined).

81.1 Usage and interface (pure)

- **Library usage:**
  `:- use_package(pure).`
  or
  `:- module(...,...,[pure]).`

81.2 Known bugs and planned improvements (pure)

- Currently, the following builtin predicates/program constructs cannot be redefined, in addition to `true/0`: `(->)/2` `(,)/2` `(+)/1` `if/3`

82 Higher-order

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#146 (2001/11/15, 19:32:38 CET)

82.1 Usage and interface (`hiord_rt`)

- **Library usage:**
  `:- use_module(library(hiord_rt)).`
- **Exports:**
  - *Predicates:*
    `call/2`.

82.2 Documentation on exports (`hiord_rt`)

call/2: PREDICATE

`call(Pred,Arg1)`

There exists a set of builtin predicates of the form `call/N` with `N > 1` which execute predicate `Pred` given arguments `Arg1` ... `ArgX`. If `Pred` has already arguments `Arg1` is added to the start, the rest to the end. This predicate, when `Pred` is a variable, can be written using the special Ciao syntax `Pred(Arg1,...,ArgX)`.

83 Higher-order predicates

Author(s): Daniel Cabeza, Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#208 (2002/4/23, 19:9:14 CEST)

This library implements a few basic higher-order predicates. These add functionality to the basic higher-order functionality of Ciao. Examples of the latter are:

Using pred(1):

```
list(L, between(1,6))
list(L, functor(_,2))
list(L, >(0))
```

Using pred(2):

83.1 Usage and interface (`hiordlib`)

- **Library usage:**
  `:- use_module(library(hiordlib)).`
- **Exports:**
  - *Predicates:*
    `map/3`, `foldl/4`, `minimum/3`.

83.2 Documentation on exports (`hiordlib`)

map/3: PREDICATE

Meta-predicate with arguments: `map(?,pred(2),?)`.

Usage: `map(LList,Op,RList)`

- *Description:* Examples of use:

```
map([1,3,2], arg(f(a,b,c,d)), [a,c,b]) or
map([1,3,2], nth([a,b,c,d]), [a,c,b])
map(["D","C"], append("."), ["D.","C."])
```

foldl/4: PREDICATE

Meta-predicate with arguments: `foldl(?,?,pred(3),?)`.

Usage: `foldl(List,Seed,Op,Result)`

- *Description:* Example of use:

```
?- foldl(["daniel","cabeza","gras"], "",
         (''(X,Y,Z) :- append(X, " "||Y, Z)), R).

R = "daniel cabeza gras " ?
```

minimum/3: PREDICATE

Meta-predicate with arguments: `minimum(?,pred(2),?)`.

Usage: `minimum(?List,+SmallerThan,?Minimum)`

- *Description:* `Minimum` is the smaller in the nonempty list `List` according to the relation `SmallerThan`: `SmallerThan(X, Y)` succeeds iff X is smaller than Y.
- *The following properties should hold at call time:*

  `?List` is a list. (`basic_props:list/1`)

  `+SmallerThan` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

  `?Minimum` is any term. (`basic_props:term/1`)

84 Terms with named arguments -records/feature terms

Author(s): Daniel Cabeza and Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#118 (2001/8/28, 15:7:22 CEST)

This library package provides syntax which allows accessing term arguments by name (these terms are sometimes also referred to as *records*, and are also similar to *feature terms* [AKPS92]).

84.1 Usage and interface (argnames)

- **Library usage:**
  `:- use_package(argnames).`
  or
  `:- module(...,...,[argnames]).`
- **New operators defined:**
  `$/2` [150,xfx], `=>/2` [950,xfx], `argnames/1` [1150,fx].
- **New declarations defined:**
  `argnames/1`.

84.2 Documentation on new declarations (argnames)

argnames/1: DECLARATION

Usage: `:- argnames(ArgNamedPredSpec).`

– *Description:* An `argnames/1` declaration assigns names to the argument positions of terms (or literal/goals) which use a certain functor/arity. This allows referring to these arguments by their name rather than by their argument position. Sometimes, argument names may be clearer and easier to remember than argument positions, specially for predicates with many arguments. Also, in some cases this may allow adding arguments to certain predicates without having to change the code that uses them. These terms with named arguments are sometimes also referred to as records, and are also similar to feature terms [AKPS92]. For example, in order to write a program for the *zebra* puzzle we might declare:

```
:- use_package([argnames]).
:- argnames house(color, nation, pet, drink, car).
```

which first includes the package and then assigns a name to each of the arguments of any term (or literal/goal) with `house/5` as the main functor.

Once an `argnames/1` is given, is possible to use the names to refer to the arguments of any term (or literal/goal) which has the same main functor as that of the term which appears in the `argnames/1` declaration. This is done by first writing the functor name, then the infix operator `$`, and then, between curly brackets, zero, one, or more pairs *argument-name*`=>`*argument-value*, separated by commas (i.e., the infix operator `=>` is used between the name and the value). Again, argument names must be atomic. Argument values can be any term. Arguments which are not specified are assumed to have a value of "`_`" (i.e., they are left unconstrained).

Thus, after the declaration for `house/5` in the example above, any ocurrence in that code of, for example, `house${nation=>Owns_zebra,pet=>zebra}` is exactly equivalent to `house(_,Owns_zebra,zebra,_,_)`. Also, `house${}` is equivalent to `house(_,_,_,_,_)`. The actual zebra puzzle specification might include a clause such as:

```
zebra(Owns_zebra, Drinks_water, Street) :-
   Street = [house${},house${},house${},house${},house${}],
   member(house${nation=>Owns_zebra,pet=>zebra}, Street),
   member(house${nation=>Drinks_water,drink=>water}, Street),
   member(house${drink=>coffee,color=>green}, Street),
   left_right(house${color=>ivory}, house${color=>green}, Street),
   member(house${car=>porsche,pet=>snails}, Street),
        ...
```

Any number of `argnames/1` declarations can appear in a file, one for each functor whose arguments are to be accessed by name. As with other packages, argument name declarations are *local to the file* in which they appear. The `argnames/1` declarations affect only program text which appears after the declaration. It is easy to make a set of declarations affect several files for example by putting such declarations in a sepatate file which is included by all such files.

An `argnames/1` declaration does not change in any way the internal representation of the associated terms and does not affect run-time efficiency. It is simply syntactic sugar.

84.3 Other information (argnames)

Two simple examples of the use of the argnames library package follow.

84.3.1 Using argument names in a toy database

```
:- module(simple_db,_,[argnames,assertions,regtypes]).
:- use_module(library(aggregates)).

:- comment(title,"A simple database application using argument names").

:- pred product/4 :: int * string * string * int.

:- argnames
product( id,    description,    brand,          quantity        ).
%       ------------------------------------------------------
product(  1,    "Keyboard",     "Logitech",     6               ).
product(  2,    "Mouse",        "Logitech",     5               ).
product(  3,    "Monitor",      "Philips",      3               ).
product(  4,    "Laptop",       "Dell",         4               ).

% Compute the stock of products from a given brand.
% Note call to findall is equivalent to: findall(Q,product(_,_,Brand,Q),L).
brand_stock(Brand,Stock) :-
        findall(Q,product${brand=>Brand,quantity=>Q},L),
        sumlist(L,Stock).

sumlist([],0).
sumlist([X|T],S) :-
```

```
        sumlist(T,S1),
        S is X + S1.
```

84.3.2 Complete code for the zebra example

```
:- module(_,zebra/3,[argnames]).

/*     There are five consecutive houses, each of a different
color and inhabited by men of different nationalities. They each
own a different pet, have a different favorite drink, and drive a
different car.

1.   The Englishman lives in the red house.
2.   The Spaniard owns the dog.
3.   Coffee is drunk in the green house.
4.   The Ukrainian drinks tea.
5.   The green house is immediately to the right of the ivory
     house.
6.   The Porsche driver owns snails.
7.   The Masserati is driven by the man who lives in the yellow
     house.
8.   Milk is drunk in the middle house.
9.   The Norwegian lives in the first house on the left.
10.  The man who drives a Saab lives in the house next to the man
     with the fox.
11.  The Masserati is driven by the man in the house next to the
     house where the horse is kept.
12.  The Honda driver drinks orange juice.
13.  The Japanese drives a Jaguar.
14.  The Norwegian lives next to the blue house.

The problem is: Who owns the Zebra?  Who drinks water?
*/

:- argnames house(color, nation, pet, drink, car).

zebra(Owns_zebra, Drinks_water, Street) :-
        Street = [house${},house${},house${},house${},house${}],
        member(house${nation => Owns_zebra, pet => zebra}, Street),
        member(house${nation => Drinks_water, drink => water}, Street),
        member(house${nation => englishman, color => red}, Street),
        member(house${nation => spaniard, pet => dog}, Street),
        member(house${drink => coffee, color => green}, Street),
        member(house${nation => ukrainian, drink => tea}, Street),
        left_right(house${color => ivory}, house${color => green}, Street),
        member(house${car => porsche, pet => snails}, Street),
        member(house${car => masserati, color => yellow}, Street),
        Street = [_, _, house${drink => milk}, _, _],
        Street = [house${nation => norwegian}|_],
        next_to(house${car => saab}, house${pet => fox}, Street),
        next_to(house${car => masserati}, house${pet => horse}, Street),
```

```
        member(house${car => honda, drink => orange_juice}, Street),
        member(house${nation => japanese, car => jaguar}, Street),
        next_to(house${nation => norwegian}, house${color => blue}, Street).


member(X,[X|_]).
member(X,[_|Y]) :- member(X,Y).

left_right(L,R,[L,R|_]).
left_right(L,R,[_|T]) :- left_right(L,R,T).

next_to(X,Y,L) :- left_right(X,Y,L).
next_to(X,Y,L) :- left_right(Y,X,L).
```

84.4 Known bugs and planned improvements (argnames)

- It would be nice to add a mechanism to portray terms with named arguments in a special (user definable) way.

85 functions (library)

85.1 Usage and interface (functions)

- **Library usage:**
  `:- use_package(functions).`
  or
  `:- module(...,...,[functions]).`
- **New operators defined:**
  `function/1` [1150,fx], `:=/2` [800,xfx], `~/1` [50,fx], `^^/1` [910,fx].
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`.

86 global (library)

Version: 0.4#5 (1998/2/24)

86.1 Usage and interface (global)

- **Library usage:**
  `:- use_module(library(global)).`
- **Exports:**
  - *Predicates:*
    `set_global/2`, `get_global/2`, `push_global/2`, `pop_global/2`, `del_global/1`.

86.2 Documentation on exports (global)

set_global/2: PREDICATE

No further documentation available for this predicate.

get_global/2: PREDICATE

No further documentation available for this predicate.

push_global/2: PREDICATE

No further documentation available for this predicate.

pop_global/2: PREDICATE

No further documentation available for this predicate.

del_global/1: PREDICATE

No further documentation available for this predicate.

87 Independent and-parallel execution

Author(s): Manuel Carro, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#160 (2001/11/27, 12:35:53 CET)

Note: This is just a partial first shot. The real library still needs to be written. Not difficult, just no time...

This library will eventually allow and-parallel execution of goals in (Herbrand-)independent fashion. It resembles the execution rules of &-Prolog [HG90]. Basically, goals are run in and-parallel *provided that their arguments do not share bindings*, i.e., are not bound to terms which contain a common variable.

87.1 Usage and interface (andprolog)

- **Library usage:**

  `:- use_package(andprolog).`

  or

  `:- module(...,...,[andprolog]).`
- **New operators defined:**

  `&/2` [950,xfy].

87.2 Documentation on internals (andprolog)

&/2: PREDICATE

`&(GoalA,GoalB)`

`GoalA` and `GoalB` are run in independent and-parallel fashion. This is just a first sketch, and valid only for deterministic independent goals. The use is as

```
q:- a & b.
```

which would start `a` and `b` in separate threads (possibly in parallalel, if the machine architecture and operating system allows that), and continue when **both** have finished. This type of execution is safe only when `a` and `b` are independent in the sense of variable sharing. This condition can be tested with the `indep/2` predicate.

active_agents/1: PREDICATE

`active_agents(NumberOfAgents)`

Tests/sets the `NumberOfAgents` which are active looking for goals to execute. As for now, those agents are resource-consuming, even when they are just looking for work, and not executing any user goals.

indep/2: PREDICATE

`indep(X,Y)`

`X` and `Y` are *independent*, i.e., they are bound to terms which have no variables in common. For example, `indep(X,Y)` holds for `X=f(Z),Y=g(K)` and also for `X=f(a),Y=X` (since both `X` and `Y` are bound to ground terms). It does not hold for `X=f(Z),Y=g(Z)` and for `X=Y`.

indep/1: PREDICATE

`indep(X)`

`X` is a list of lists of length two, i.e., a list of the form `[[T1, T2], [T3, T4], ...]`. The variables in each pair of the list `X` are tested for independence using `indep/2`. This list-of-pairs format is the output of several independddnce analyzers for pair sharing.

87.3 Known bugs and planned improvements (`andprolog`)

- **Beware:** the current code is just a partial first shot. It is provided for the sole purpose of experimentation and development.
- The fact that only the first solution is returned for the conjunction is due to performance issues (and lack of time), and we expect to remove it in a near future.
- CGEs (i.e., `=>`) are not supported.
- The `indep/1`, `indep/2`, and `ground/1` tests are not very efficient; they will be replaced by native versions (taken from the &-Prolog code) in the future.

88 Andorra execution

Author(s): Claudio Vaucheret, Francisco Bueno.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#144 (2001/11/12, 17:57:47 CET)

This package allows the execution under the Basic Andorra Model [War88]. The model classifies goals as a *determinate goal*, if at most one clause matches the goal, or nondeterminate goal, otherwise. In this model a goal is delayed until either it becomes determinate or it becomes the leftmost goal and no determinate goal is available. The implementation of this selection rule is based on the use of attributed variables [Hol92,Hol90].

In order to test determinacy we verify only the heads of clauses and builtins in the bodies of clauses before the first cut, if any. By default, determinacy of a goal is detected dynamically: when called, if at most one clause matches, it is executed; otherwise, it is delayed. For goals delayed the test is repeated each time a variable appearing in the goal is instantiated. In addition, efficiency can be improved by using declarations that specify the determinacy conditions. These will be considered for testing instead of the generic test on all clauses that can match.

As with any other Ciao package, the andorra computation rule affects only the module that uses the package. If execution passes across two modules that use the computation rule, determinate goals are run in advance *within* one module and also within the other module. But determinate goals of one module do not run ahead of goals of the other module.

It is however possible to preserve the computation rule for calls to predicates defined in other modules. These modules should obviously also use this package. In addition *all* predicates from such modules should imported, i.e., the directive `:- use_module(module)`, should be used in this case instead of `:- use_module(module,[...])`. Otherwise calls to predicates outside the module will only be called when they became the leftmost goal.

88.1 Usage and interface (andorra)

- **Library usage:**
  `:- use_package(andorra).`
  or
  `:- module(...,...,[andorra]).`
- **Exports:**
  - *Regular Types:*
    `detcond/1`, `path/1`.
- **New operators defined:**
  `?\=/2` [700,xfx], `?=/2` [700,xfx].
- **New declarations defined:**
  `determinate/2`.

88.2 Documentation on new declarations (andorra)

determinate/2: DECLARATION

`:- determinate(Pred,Cond).`

Declares determinacy conditions for a predicate. Conditions `Cond` are on variables of arguments of `Pred`. For example, in:

```
:- determinate(member(A,B,C), ( A ?= term(B,[1])  ; C?=[_|_]) ).

member(A,[A|B],B).
member(A,[B|C],[B|D]) :-
        A==B,
        member(A,C,D).
```

the declaration states that a call `member(A,B,C)` is determinate when either `A` doesn't unify with the first argument of `B` or `C` doesn't unify with `[_|_]`.

Usage: `:- determinate(Pred,Cond).`

- *Description:* States that the predicate `Pred` is determinate when `Cond` holds.
- *The following properties should hold at call time:*

  `Pred` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(`basic_props:predname/1`)

`Cond` is a determinacy condition. (`user(... /andorra_doc):detcond/1`)

88.3 Documentation on exports (andorra)

detcond/1: REGTYPE

Defined by:

```
detcond(ground(X)) :-
        var(X).
detcond(nonvar(X)) :-
        var(X).
detcond(instatiated(A,Path)) :-
        var(A),
        list(Path,int).
detcond(?\=(Term1,Term2)) :-
        path(Term1),
        path(Term2).
detcond(?=(Term1,Term2)) :-
        path(Term1),
        path(Term2).
detcond(Test) :-
        test(Test).
```

- `ground/1` and `nonvar/1` have the usual meaning.
- `instatiated(A,Path)` means that the subterm of `A` addressed by `Path` is not a variable. `Path` is a list of integer numbers describing a path to the subterm regarding the whole term A as a tree. For example, `instantiated(f(g(X),h(i(Z),Y)),[2,1])` tests whether `i(Z)` is not a variable.
- `Term1 ?\= Term2` means "terms `Term1` and `Term2` do not unify (when instantiated)". `Term1` and `Term2` can be either an argument of the predicate or a term `term(V,Path)`, which refers to the subterm of `V` addressed by `Path`.
- `Term1 ?= Term2` means "terms `Term1` and `Term2` unify (when instantiated)". The same considerations above apply to `Term1` and `Term2`.
- any other test that does not unify variables can also be used (`==/2`, `\==/2`, `atomic/1`).

Usage: `detcond(X)`

– *Description:* `X` is a determinacy condition.

path/1: REGTYPE

Defined by:

```
path(X) :-
        var(X).
path(X) :-
        list(X,int).
```

88.4 Other information (andorra)

The andorra transformation will include the following predicates into the code of the module that uses the package. Be careful not to define predicates by these names:

- `detcond_andorra/4`
- `path_andorra/4`
- `detcond_susp/4`
- `path_susp/4`
- `list_andorra2/5`
- `test_andorra2/4`

89 Call on determinate

Author(s): José Morales, Manuel Carro.

Version: 1.7#149 (2001/11/19, 19:17:51 CET)

Offers an enriched variant of call and cut `!!/0` which executes pending goals when the computation has no more alternatives.

This library is useful to, for example, get rid of external connections once the necessary data has been obtained.

89.1 Usage and interface (`det_hook_rt`)

- **Library usage:**

  `:- use_module(library(det_hook_rt)).`

  in which case, `!!/0` is not available.

  Typically, this library is used as a package:

  `:- use_package(det_hook).`
- **Exports:**
  - *Predicates:*

    `det_try/3`.

89.2 Documentation on exports (`det_hook_rt`)

det_try/3: PREDICATE

Meta-predicate with arguments: `det_try(goal,goal,goal)`.

Usage: `det_try(Goal,OnCut,OnFail)`

- *Description:* `Action` is called, and `OnCut` and `OnFail` are goals to be executed when `Goal` is cut or when it finitely fails, respectively. In order for this to work, cutting must be performed in a special way, by usin the `!!/0` predicate, also provided by this module.
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

  `OnCut` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

  `OnFail` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

89.3 Documentation on internals (`det_hook_rt`)

!!/0: PREDICATE

Usage:

- *Description:* Performs a special cut which prunes alternatives away, as the usual cut, but which also executes the goals specified as `OnCut` for any call in the scope of the cut.

89.4 Other information (det_hook_rt)

As an example, the program

```
:- module(_, _, [det_hook]).

enumerate(X):-
        display(enumerating), nl,
        OnCut = (display('goal cut'), nl),
        OnFail = (display('goal failed'), nl),
        det_try(enum(X), OnCut, OnFail).

enum(1).
enum(2).
enum(3).
```

behaves as follows:

```
?- enumerate(X).
enumerating

X = 1 ? ;

X = 2 ? ;

X = 3 ? ;
goal failed
```

(note the message inserted on failure). The execution can be cut as follows:

```
?- use_package(det_hook).
{Including /home/clip/lib/ciao/ciao-1.7/library/det_hook/det_hook.pl
}

yes
?- enumerate(X), '!!'.
enumerating
goal cut

X = 1 ? ;

no
```

89.5 Known bugs and planned improvements (det_hook_rt)

- If the started goals do not exhaust their solutions, and '!!'/0 is not used, the database will populate with facts which will be consulted the next time a '!!'/0 is used. This could cause incorrect executions.

90 Miscellaneous predicates

Author(s): Manuel Carro, Daniel Cabeza.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.3#95 (1999/11/8, 18:37:30 MET)

This module implements some miscellaneous non-logical (but sometimes very useful) predicates.

90.1 Usage and interface (odd)

- **Library usage:**
  `:- use_module(library(odd)).`
- **Exports:**
  - *Predicates:*
    `setarg/3`, `undo/1`.

90.2 Documentation on exports (odd)

setarg/3: PREDICATE

Usage: `setarg(Index,Term,NewArg)`

- *Description:* Replace destructively argument `Index` in `Term` by `NewArg`. The assignment is undone on backtracking. This is a major change to the normal behavior of data assignment in Ciao Prolog.
- *The following properties should hold at call time:*
  `Index` is currently instantiated to an integer. (`term_typing:integer/1`)
  `Term` is a compound term. (`basic_props:struct/1`)
  `NewArg` is any term. (`basic_props:term/1`)
- *The following properties hold upon exit:*
  `Index` is currently instantiated to an integer. (`term_typing:integer/1`)
  `Term` is a compound term. (`basic_props:struct/1`)
  `NewArg` is any term. (`basic_props:term/1`)

undo/1: PREDICATE

Usage: `undo(Goal)`

- *Description:* `call(Goal)` is executed on backtracking. This is a major change to the normal control of Ciao Prolog execution.
- *The following properties should hold at call time:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)
- *The following properties hold upon exit:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

91 Delaying predicates (freeze)

Author(s): Manuel Carro, Daniel Cabeza.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#72 (2000/3/19, 19:9:14 CET)

This library offers a simple implementation of `freeze/2`, `frozen/2`, etc. [Col82,Nai85,Nai91,Car87] based on the use of attributed variables [Hol92,Hol90].

91.1 Usage and interface (`freeze`)

- **Library usage:**
  `:- use_module(library(freeze)).`
- **Exports:**
  - *Predicates:*
    `freeze/2`, `frozen/2`.
  - *Multifiles:*
    `verify_attribute/2`, `combine_attributes/2`.

91.2 Documentation on exports (`freeze`)

freeze/2: PREDICATE

Meta-predicate with arguments: `freeze(?,goal)`.

Usage: `freeze(X,Goal)`

- *Description:* If `X` is free delay `Goal` until `X` is non-variable.
- *The following properties should hold at call time:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

frozen/2: PREDICATE

Meta-predicate with arguments: `frozen(?,goal)`.

Usage: `frozen(X,Goal)`

- *Description:* `Goal` is currently delayed until variable `X` becomes bound.
- *The following properties should hold upon exit:*
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

91.3 Documentation on multifiles (`freeze`)

verify_attribute/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

combine_attributes/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

92 Delaying predicates (when)

Author(s): Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#3 (2000/7/21, 11:54:59 CEST)

`when/2` delays a predicate until some condition in its variable is met. For example, we may want to find out the maximum of two numbers, but we are not sure when they will be instantiated. We can write the standard `max/3` predicate (but changing its name to `gmax/3` to denote that the first and second arguments must be ground) as

```
gmax(X, Y, X):- X > Y, !.
gmax(X, Y, Y):- X =< Y.
```

and then define a 'safe' `max/3` as

```
max(X, Y, Z):-
        when((ground(X),ground(Y)), gmax(X, Y, Z)).
```

which can be called as follows:

```
?- max(X, Y, Z) , Y = 0, X = 8.

X = 8,
Y = 0,
Z = 8 ?

yes
```

Alternatively, `max/3` could have been defined as

```
max(X, Y, Z):-
        when(ground((X, Y)), gmax(X, Y, Z)).
```

with the same effects as above. More complex implementations are possible. Look, for example, at the `max.pl` implementation under the `when` library directory, where a `max/3` predicate is implemented which waits on all the arguments until there is enough information to determine their values:

```
?- use_module(library('when/max')).

yes
?- max(X, Y, Z), Z = 5, Y = 4.

X = 5,
Y = 4,
Z = 5 ?

yes
```

92.1 Usage and interface (when)

- **Library usage:**
  `:- use_module(library(when)).`
- **Exports:**
  - *Predicates:*
    `when/2`.
  - *Regular Types:*
    `wakeup_exp/1`.
  - *Multifiles:*
    `verify_attribute/2`, `combine_attributes/2`.
- **Other modules used:**
  - *System library modules:*
    `terms_vars`, `sort`, `sets`.

92.2 Documentation on exports (when)

when/2: PREDICATE

Meta-predicate with arguments: `when(?,goal)`.

Usage: `when(WakeupCond,Goal)`

- *Description:* Delays / executes `Goal` according to `WakeupCond` given. The `WakeupCond`s now acceptable are `ground(T)` (`Goal` is delayed until `T` is ground), `nonvar(T)` (`Goal` is delayed until `T` is not a variable), and conjunctions and disjunctions of conditions:

```
wakeup_exp(ground(_1)).
wakeup_exp(nonvar(_1)).
wakeup_exp((C1,C2)) :-
        wakeup_exp(C1),
        wakeup_exp(C2).
wakeup_exp((C1;C2)) :-
        wakeup_exp(C1),
        wakeup_exp(C2).
```

  `when/2` only fails it the `WakeupCond` is not legally formed. If `WakeupCond` is met at the time of the call no delay mechanism is involved — but there exists a time penalty in the condition checking.

  In case that an instantiation fires the execution of several predicates, the order in which these are executed is not defined.
- *The following properties should hold at call time:*
  `WakeupCond` is a legal expression for delaying goals. (`when:wakeup_exp/1`)
  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

wakeup_exp/1: REGTYPE

Usage: `wakeup_exp(T)`

– *Description:* `T` is a legal expression for delaying goals.

92.3 Documentation on multifiles (`when`)

verify_attribute/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

combine_attributes/2: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

92.4 Known bugs and planned improvements (`when`)

- Redundant conditions are not removed.
- Floundered goals are not appropriately printed.

93 Active modules (high-level distributed execution)

Author(s): Manuel Hermenegildo, Daniel Cabeza.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#205 (2002/4/22, 20:52:9 CEST)

Active modules [CH95] provide a high-level model of inter-process communication and distributed execution (note that using Ciao's communication and concurrency primitives, such as sockets, concurrent predicates, etc.). An *active module* (or an *active object*) is an ordinary module to which computational resources are attached, and which resides at a given location on the network. Compiling an active module produces an executable which, when running, acts as a server for a number of predicates, the predicates exported by the module. Predicates exported by an active module can be accessed by a program on the network by simply "using" the module, which then imports such "remote predicates." The process of loading an active module does not involve transferring any code, but rather setting up things so that calls in the module using the active module are executed as remote procedure calls to the active module. This occurs in the same way independently of whether the active module and the using module are in the same machine or in different machines across the network.

Except for having to compile it in a special way (see below), an active module is identical from the programmer point of view to an ordinary module. A program using an active module imports it and uses it in the same way as any other module, except that it uses "`use_active_module`" rather than "`use_module`" (see below). Also, an active module has an address (network address) which must be known in order to use it. In order to use an active module it is necessary to know its address: different "protocols" are provided for this purpose (see below).
[1]

From the implementation point of view, active modules are essentially daemons: executables which are started as independent processes at the operating system level. Communication with active modules is implemented using sockets (thus, the address of an active module is an IP socket address in a particular machine). Requests to execute goals in the module are sent through the socket by remote programs. When such a request arrives, the process running the active module takes it and executes it, returning through the socket the computed answers. These results are then taken and used by the remote processes. Backtracking over such remote calls works as usual and transparently. The only limitation (this may change in the future, but it is currently done for efficiency reasons) is that all alternative answers are precomputed (and cached) upon the first call to an active module and thus *an active module should not export a predicate which has an infinite number of answers.*

The first thing to do is to select a method whereby the client(s) (the module(s) that will use the active module) can find out in which machine/port (IP address/socket number) the server (i.e., the active module) will be listening once started, i.e., a "protocol" to communicate with the active module. The easiest way to do this is to make use of the redezvous methods which are provided in the Ciao distribution in the `library/actmods` directory; currently, `tmpbased...`, `filebased...`, and `webbased...`.

The first one is based on saving the IP address and socket number of the server in a file in a predefined directory (generally `/tmp`, but this can be changed by changing `tmpbased_common.pl`).

The second one is similar but saves the info in the directory in which the server is started (as `<`*module_name*`>.addr`), or in the directory that a `.addr` file, if it exists, specifies. The clients must be started in the same directory (or have access to a file `.addr` specifying the same

[1] It is also possible to provide active modules via a WWW address. However, we find it more straightforward to simply use socket addresses. In any case, this is generally hidden inside the access method and can be thus made transparent to the user.

directory). However, they can be started in different machines, provided this directory is shared (e.g., by NFS or Samba), or the file can be moved to an appropriate directory on a different machine –provided the full path is the same.

The third one is based on a name server for active modules. When an active module is compiled, it communicates its address to the name server. When the client of the active module wants to communicate with it, it asks the name server the active module address. This is all done transparently to the user. The name server must be running when the active module is compiled (and, of course, when the application using it is executed). The location of the name server for an application must be specified in an application file named `webbased_common.pl` (see below).

These rendezvous methods are encoded in two modules: a first one, called `...publish.pl`, is used by the server to publish its info. The second one, called `...locate.pl`, is used by the client(s) to locate the server info. For efficiency, the client methods maintain a cache of addresses, so that the server information only needs to be read from the file system the first time the active module is accessed.

Active modules are compiled using the `-a` option of the Ciao compiler (this can also be done from the interactive top-level shell using `make_actmod/2`). For example, issuing the following command:

```
ciaoc -a 'actmods/filebased_publish' simple_server
```

compiles the simple server example that comes with the distribution (in the `actmods/example` directory). The `simple_client_with_main` example (in the same directory) can be compiled as usual:

```
ciaoc simple_client_with_main
```

Note that the client uses the `actmods` package, specifies the rendezvous method by importing `library('actmods/filebased_locate')`, and explicitely imports the "remote" predicates (*implicit imports will not work*). Each module using the `actmods` package *should only use one of the rendezvous methods.*

Now, if the server is running (e.g., `simple_server &` in Un*x or double-clicking on it in Win32) when the client is executed it will connect with the server to access the predicate(s) that it imports from it.

A simpler even client `simple_client.pl` can be loaded into the top level and its predicates called as usual (and they will connect with the server if it is running).

93.0.1 Active module name servers

An application using a name server for active modules must have a file named `webbased_common.pl` that specifies where the name server resides. It must have the `URL` and the path which corresponds to that `URL` in the file system of the server machine (the one that hosts the `URL`) of the file that will hold the name server address.

The current distribution provides a file `webbased_common.pl` that can be used (after proper setting of its contents) for a server of active modules for a whole installation. Alternatively, particular servers for each application can (or could) be set up...

The current distribution also provides a module that can be used as name server by any application. It is in file `examples/webbased_server/webbased_server.pl`.

To set up a name server edit `webbased_common.pl` to change its contents appropriately as described above (`URL` and corresponding complete file path). Then recompile this library module:

```
ciaoc -c webbased_common
```

The name server has to be compiled as an active module itself:

```
ciaoc -a actmods/webserver_publish webbased_server
```

It has to be started in the server machine before the application and its active modules are compiled.

Alternatively, you can copy `webbased_common.pl` and use it to set up name servers for particular applications. Currently, this is a bit complicated. You have to ensure that the name server, the application program, and all its active modules are compiled and executed with the same `webbased_common.pl` module. One way to do this is to create a subdirectory `actmods` under the directory of your application, copy `webbased_common.pl` to it, modify it, and then compile the name server, the application program, and its active modules using a library path that guarantees that your `actmods` directory is located by the compiler before the standard Ciao library. The same applies for when running all of them if the library loading is dynamic.

Addresses of active modules are saved by the name server in a subdirectory `webbased_db` of the directory where you start it —see `examples/webbased_server/webbased_db/webbased_server`). This allows to restart the server right away if it dies (since it saves its state). This directory should be cleaned up regularly of addresses of active modules which are no more active. To do this, stop the server —by killing it (its pid is in `PATH/FILE`), and restart it after cleaning up the files in the above mentioned directory.

93.0.2 Active modules as agents

It is rather easy to turn Ciao active modules into agents for some kind of applications. The directory `examples/agents` contains a (hopefully) self-explanatory example.

93.1 Usage and interface (actmods)

- **Library usage:**
  `:- use_package(actmods).`
  or
  `:- module(...,...,[actmods]).`
- **New declarations defined:**
  `use_active_module/2`.

93.2 Documentation on new declarations (actmods)

use_active_module/2: DECLARATION

Usage: `:- use_active_module(AModule,Predicates).`

- *Description:* Specifies that this code imports from the *active module* defined in `AModule` the predicates in `Imports`. The imported predicates must be exported by the active module.
- *The following properties should hold at call time:*
  `AModule` is a source name. (`streams_basic:sourcename/1`)
  `Predicates` is a list of `prednames`. (`basic_props:list/2`)

93.3 Known bugs and planned improvements (`actmods`)

- The package provides no means for security: the accessing application must take care of this (?).
- It can happen that there is a unique process for an active module serving calls from several different simultaneous executions of the same application. In this case, there might be unwanted interactions (e.g., if the active module has state).
- Applications may fail if the name server or an active module is restarted during execution of the application (since they restart at a different port than the one cached by the application).
- One may want name servers to reside at a fixed and known machine and port number (this is known as a *service* and is defined in `/etc/services` in a Un*x machine). Currently, the port number changes in each invocation of the server.
- One may want to have one name server dedicated to a single application. Currently, there is no easy way to do this.

94 Breadth-first execution

Author(s): Daniel Cabeza, Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#143 (2000/5/12, 13:54:34 CEST)

This package implements breadth-first execution of predicates. Predicates written with operators `'<-'/1` (facts) and `'<-'/2` (clauses) are executed using breadth-first search. This may be useful in search problems when a complete proof procedure is needed. An example of code would be:

```
:- module(chain, _, [bf]).

test(bf) :- bfchain(a,d).
test(df) :- chain(a,d).   % loops!

bfchain(X,X) <- .
bfchain(X,Y) <- arc(X,Z), bfchain(Z,Y).

chain(X,X).
chain(X,Y) :- arc(X,Z), chain(Z,Y).

arc(a,b).
arc(a,d).
arc(b,c).
arc(c,a).
```

There is another version, called `bf/af`, which ensures AND-fairness by goal shuffling. This version correctly says "`no`" executing the following test:

```
:- module(sublistapp, [test/0,sublistapp/2], ['bf/af']).

test :- sublistapp([a],[b]).

sublistapp(S,L) <- append(_,S,Y), append(Y,_,L).

append([], L, L) <- .
append([X|Xs], L, [X|Ys]) <- append(Xs, L, Ys).
```

94.1 Usage and interface (`bf`)

- **Library usage:**
  `:- use_package(bf).`
  or
  `:- module(...,...,[bf]).`
- **New operators defined:**
  `<-/2` [1200,xfx], `<-/1` [1200,xf].

94.2 Known bugs and planned improvements (`bf`)

- Does not correctly work in user files.

95 Iterative-deepening execution

Author(s): Claudio Vaucheret, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#119 (2001/8/28, 15:39:1 CEST)

This package applies a *compiling control* technique to implement *depth first iterative deepening* execution [Kor85]. It changes the usual *depth-first* computation rule by *iterative-deepening* on those predicates specifically marked. This is very useful in search problems when a complete proof procedure is needed.

When this computation rule is used, first all goals are expanded only up to a given depth. If no solution is found or more solutions are needed by backtracking, the depth limit is incremented and the whole goal is repeated. Although it might seem that this approach is very inefficient because all higher levels are repeated for the deeper ones, it has been shown that is performs only about b/(b - 1) times as many operations than the corresponding breadth-first search, (where b is the branching factor of the proof tree) while the waste of memory is the same as depth first.

The usage is by means of the following directive:

```
:- iterative(Name, FirstCut, Formula).
```

which states than the predicate 'Name' given in functor/arity form will be executed using iterative deepening rule starting at the depth 'FirstCut' with depth being incremented by the predicate 'Formula'. This predicate compute the new depth using the previous one. It must implement a dilating function i.e. the new depth must be greater. For example, to start with depth 5 and increment by 10 you can write:

```
:- iterative(p/1,5,f).
f(X,Y) :- Y is X + 10.
```

or if you prefer,

```
:- iterative(p/1,5,(_(X,Y):- Y is X + 10)).
```

You can also use a fourth parameter to set a limiting depth. All goals below the given depth limit simply fail. Thus, with the following directive:

```
:- iterative(p/1,5,(_(X,Y):- Y is X + 10),100).
```

all goals deeper than 100 will fail.

An example of code using this package would be:

The order of solutions are first the shallower and then the deeper. Solutions which are between two cutoff are given in the usual left to right order. For example,

It is possible to preserve the iterative-deepening behavior for calls to predicates defined in other modules. These modules should obviously also use this package. In addition *all* predicates from such modules should imported, i.e., the directive `:- use_module(module)`, should be used in this case instead of `:- use_module(module,[...])`. Otherwise calls to predicates outside the module will be treated in the usual way i.e. by depth-first computation.

Another complete proof procedure implemented is the `bf` package (breadth first execution).

95.1 Usage and interface (`id`)

- **Library usage:**
  `:- use_package(id).`
  or
  `:- module(...,...,[id]).`

96 Constraint programming over rationals

Author(s): Christian Holzbaur, Daniel Cabeza.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#156 (2000/5/30, 11:0:51 CEST)

Note: This package is currently being adapted to the new characteristics of the Ciao module system. This new version now works right now to some extent, but it is under further development at the moment. Use with (lots of) caution.

96.1 Usage and interface (clpq)

- **Library usage:**

  ```
  :- use_package(clpq).
  ```

  or

  ```
  :- module(...,...,[clpq]).
  ```

96.2 Other information (clpq)

96.2.1 Some CLP(Q) examples

(Other examples can be found in the source and library directories.)

- 'Reversible' Fibonacci (clpq):

```
:- module(_, [fib/2], []).
:- use_package(clpq).

fib(X,Y):- X .=. 0, Y .=. 0.
fib(X,Y):- X .=. 1, Y .=. 1.
fib(N,F) :-
        N .>. 1,
        N1 .=. N - 1,
        N2 .=. N - 2,
        fib(N1, F1),
        fib(N2, F2),
        F .=. F1+F2.
```

- Matrix multiplication (clpq):

```
:- use_package(clpq).
:- use_module(library(write)).

mmultiply([],_,[]).
mmultiply([V0|Rest], V1, [Result|Others]):-
            mmultiply(Rest, V1, Others),
                multiply(V1,V0,Result).

multiply([],_,[]).
```

```
multiply([V0|Rest], V1, [Result|Others]):-
            multiply(Rest, V1, Others),
                vmul(V0,V1,Result).

vmul([],[],0).
vmul([H1|T1], [H2|T2], Result):-
        vmul(T1,T2, Newresult),
        Result .=. H1*H2+Newresult.

matrix(1,[[1,2,3,4,5],[4,0,-1,5,6],[7,1,-2,8,9],[-1,0,1,3,2],[1,5,-3,2,4]]).
matrix(2,[[3,2,1,0,-1],[-2,1,3,0,2],[1,2,0,-1,5],[1,3,2,4,5],[-5,1,4,2,2]]).

%% Call with: ?- go(M).

go(M):-
        matrix(1,M1),
        matrix(2,M2),
        mmultiply(M1, M, M2).
```

- Queens (clpq):

```
:- use_package(clpq).

queens(N, Qs) :- constrain_values(N, N, Qs), place_queens(N, Qs).

constrain_values(0, _N, []).
constrain_values(N, Range, [X|Xs]) :-
        N .>. 0, X .>. 0, X .=<. Range,
        N1 .=. N - 1,
        constrain_values(N1, Range, Xs), no_attack(Xs, X, 1).

no_attack([], _Queen, _Nb).
no_attack([Y|Ys], Queen, Nb) :-
        Queen .<>. Y+Nb,
        Queen .<>. Y-Nb,
        Nb1 .=. Nb + 1,
        no_attack(Ys, Queen, Nb1).

place_queens(0, _).
place_queens(N, Q) :-
        N > 0, member(N, Q), N1 is N-1, place_queens(N1, Q).
```

97 Constraint programming over reals

Author(s): Christian Holzbaur, Daniel Cabeza.

Note: This package is currently being adapted to the new characteristics of the Ciao module system. This new version now works right now to some extent, but it under further development at the moment. Use with (lots of) caution.

97.1 Usage and interface (clpr)

- **Library usage:**

  ```
  :- use_package(clpr).
  ```

  or

  ```
  :- module(...,...,[clpr]).
  ```

97.2 Other information (clpr)

97.2.1 Some CLP(R) examples

(Other examples can be found in the source and library directories.)

- 'Reversible' Fibonacci (clpr):

```
:- module(_, [fib/2], []).
:- use_package(clpr).

fib(X,Y):- X .=. 0, Y .=. 0.
fib(X,Y):- X .=. 1, Y .=. 1.
fib(N,F) :-
        N .>. 1,
        N1 .=. N - 1,
        N2 .=. N - 2,
        fib(N1, F1),
        fib(N2, F2),
        F .=. F1+F2.
```

- Dirichlet problem for Laplace's equation (clpr):

```
%
% Solve the Dirichlet problem for Laplace's equation using
% Leibman's five-point finit-differenc approximation.
% The goal ?- go1 is a normal example, while the goal ?- go2
% shows output constraints for a small region where the boundary conditions
% are not specified.
%
:- use_package(clpq).
:- use_module(library(format)).
```

```
laplace([_, _]).
laplace([H1, H2, H3|T]):-
        laplace_vec(H1, H2, H3),
        laplace([H2, H3|T]).

laplace_vec([_, _], [_, _], [_, _]).
laplace_vec([_TL, T, TR|T1], [ML, M, MR|T2], [_BL, B, BR|T3]):-
        B + T + ML + MR - 4 * M .=. 0,
        laplace_vec([T, TR|T1], [M, MR|T2], [B, BR|T3]).

printmat([]).
printmat([H|T]):-
        printvec(H),
        printmat(T).

printvec([]):- nl.
printvec([H|T]):-
        printrat(H),
        printvec(T).

printrat(rat(N,D)) :- !,
        X is N/D,
        format(" ~2f",X).
printrat(N) :-
        X is N*100,
        format(" ~2d",X).

go1:-
        X =  [
      [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, _, _, _, _, _, _, _, _, _, 100],
    [100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100]
    ],
        laplace(X),
        printmat(X).

% Answer:
% 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
% 100.00 51.11 32.52 24.56 21.11 20.12 21.11 24.56 32.52 51.11 100.00
% 100.00 71.91 54.41 44.63 39.74 38.26 39.74 44.63 54.41 71.91 100.00
% 100.00 82.12 68.59 59.80 54.97 53.44 54.97 59.80 68.59 82.12 100.00
% 100.00 87.97 78.03 71.00 66.90 65.56 66.90 71.00 78.03 87.97 100.00
% 100.00 91.71 84.58 79.28 76.07 75.00 76.07 79.28 84.58 91.71 100.00
```

```
% 100.00 94.30 89.29 85.47 83.10 82.30 83.10 85.47 89.29 94.30 100.00
% 100.00 96.20 92.82 90.20 88.56 88.00 88.56 90.20 92.82 96.20 100.00
% 100.00 97.67 95.59 93.96 92.93 92.58 92.93 93.96 95.59 97.67 100.00
% 100.00 98.89 97.90 97.12 96.63 96.46 96.63 97.12 97.90 98.89 100.00
% 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00

go2([B31, M32, M33, B34, B42, B43, B12, B13, B21, M22, M23, B24]) :-
        laplace([
            [_B11, B12, B13, _B14],
            [B21, M22, M23, B24],
            [B31, M32, M33, B34],
            [_B41, B42, B43, _B44]
    ]).


% Answer:
%
% B34.=. -4*M22+B12+B21+4*M33-B43,
% M23.=.4*M22-M32-B12-B21,
% B31.=. -M22+4*M32-M33-B42,
% B24.=.15*M22-4*M32-4*B12-4*B21-M33-B13 ?
```

98 Fuzzy Prolog

Author(s): Claudio Vaucheret, Sergio Guadarrama, Francisco Bueno.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#199 (2002/4/18, 18:5:46 CEST)

This package impements an extension of prolog to deal with uncertainty. We implement a fuzzy prolog that models interval-valued fuzzy logic. This approach is more general than other fuzzy prologs in two aspects:

1. Truth values are sub-intervals on [0,1]. In fact, it could be a finite union of sub-intervals, as we will see below. Having a unique truth value is a particular case modeled with a unitary interval.
2. Truth values are propagated through the rules by means of a set of *aggregation operators*. The definition of an *aggregation operator* is a generalization that subsumes conjunctive operators (triangular norms as min, prod, etc.), disjunctive operators (triangular co-norms as max, sum, etc.), average operators (averages as arithmetic average, cuasi-linear average, etc.) and hybrid operators (combinations of previous operators).

We add uncertainty using CLP(R) instead of implementing a new fuzzy resolution as other fuzzy prologs. In this way, we use the original inference mechanism of Prolog, and we use the constraints and its operations provided by CLP(R) to handle the concept of partial truth. We represent intervals as constrains over real numbers and *aggregation operators* as operations with constraints.

Each fuzzy predicate has an additional argument which represents its truth value. We use ":~" instead of ":-" to distinguish fuzzy clauses from prolog clauses. In fuzzy clauses, truth values are obtained via an aggregation operator. There is also some syntactic sugar for defining fuzzy predicates with certain membership functions, the fuzzy counterparts of crisp predicates, and the fuzzy negation of a fuzzy predicate.

98.1 Usage and interface (`fuzzy`)

- **Library usage:**

  `:- use_package(fuzzy).`

  or

  `:- module(...,...,[fuzzy]).`
- **Exports:**
  - *Predicates:*

    `:#/2`, `fuzzy_predicate/1`, `fuzzy/1`, `fnot/1`, `:~/2`, `=>/4`.
  - *Properties:*

    `fuzzybody/1`.
  - *Regular Types:*

    `faggregator/1`.
- **New operators defined:**

  `:~/2` [1200,xfx], `:~/1` [1200,xf], `:=/2` [1200,xfx], `:=/1` [1200,xf], `:#/2` [1200,xfx], `=>/1` [1175,fx], `fnot/1` [1150,fx], `aggr/1` [1150,fx], `##/2` [1120,xfy], `<#/2` [1120,xfy], `#>/2` [1120,xfy], `fuzzy/1` [1150,fx], `fuzzy_predicate/1` [1190,fx], `fuzzy_discrete/1` [1190,fx].
- **New declarations defined:**

  `aggr/1`.

98.2 Documentation on new declarations (fuzzy)

aggr/1: DECLARATION

Usage: `:- aggr(Name).`

- *Description:* Declares `Name` an aggregator. Its binary definition has to be provided. For example:

```
:- aggr myaggr.

myaggr(X,Y,Z):- Z .=. X*Y.
```

  defines an aggregator identical to `prod`.

- *The following properties hold at call time:*

  `Name` is an atomic term (an atom or a number). (`basic_props:constant/1`)

98.3 Documentation on exports (fuzzy)

:#/2: PREDICATE

Usage: `:#(Name,Decl)`

- *Description:* Defines fuzzy predicate `Name` from the declaration `Decl`.
- *The following properties hold upon exit:*

  `Name` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

  (`basic_props:predname/1`)

  `Decl` is one of the following three:

```
fuzzydecl(fuzzy_predicate(_1)).
fuzzydecl(fuzzy(_1)).
fuzzydecl(fnot(_1)).
```

  (`user(... /fuzzy_doc):fuzzydecl/1`)

fuzzy_predicate/1: PREDICATE

Usage: `fuzzy_predicate(Domain)`

- *Description:* Defines a fuzzy predicate with piecewise linear continuous membership function. This is given by `Domain`, which is a list of pairs of domain-truth values, in increasing order and exhaustive. For example:

```
young :# fuzzy_predicate([(0,1),(35,1),(45,0),(120,0)]).
```

  defines the predicate:

```
young(X,1):- X .>=. 0, X .<. 35.
young(X,M):- X .>=. 35, X .<. 45, 10*M .=. 45-X.
young(X,0):- X .>=. 45, X .=<. 120.
```

- *The following properties should hold at call time:*

  `Domain` is a list. (`basic_props:list/1`)

fuzzy/1: PREDICATE

Usage: `fuzzy(Name)`

- *Description:* Defines a fuzzy predicate as the fuzzy counterpart of a crisp predicate `Name`. For example,

```
p_f :# fuzzy p/2
```

  defines a new fuzzy predicate `p_f/3` (the last argument is the truth value) with truth value equal to 0 if `p/2` fails and 1 otherwise.

- *The following properties should hold at call time:*

  `Name` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(`basic_props:predname/1`)

fnot/1: PREDICATE

Usage: `fnot(Name)`

- *Description:* Defines a fuzzy predicate as the fuzzy negation of another fuzzy predicate `Name`. For example,

```
notp_f :# fnot p_f/3
```

  defines the predicate:

```
notp_f(X,Y,M) :-
        p_f(X,Y,Mp),
        M .=. 1 - Mp.
```

- *The following properties should hold at call time:*

  `Name` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

(`basic_props:predname/1`)

:~/2: PREDICATE

Usage: `:~(Head,Body)`

- *Description:* Defines a fuzzy clause for a fuzzy predicate. The clause contains calls to either fuzzy or crisp predicates. Calls to crisp predicates are automatically fuzzified. The last argument of `Head` is the truth value of the clause, which is obtained as the aggregation of the truth values of the body goals. An example:

```
:- module(young2,_,[fuzzy]).

young_couple(X,Y,Mu) :~ min
        age(X,X1),
        age(Y,Y1),
        young(X1,MuX),
        young(Y1,MuY).

age(john,37).
```

```
age(rose,39).

young :# fuzzy_predicate([(0,1),(35,1),(45,0),(120,0)]).
```

so that:

```
?- young_couple(john,rose,M).

M .=. 0.6 ?
```

– *The following properties should hold at call time:*

`Head` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Body` is a clause body plus an optional aggregation operator. (`user(.../fuzzy_doc):fuzzybody/1`)

fuzzybody/1: PROPERTY

A clause body, optionally prefixed by the name of an aggregation operator. The agregators currently provided are listed under `faggregator/1`. By default, the aggregator used is `min`.

Usage: `fuzzybody(B)`

– *Description:* `B` is a clause body plus an optional aggregation operator.

faggregator/1: REGTYPE

The first three are, respectively, the T-norms: minimum, product, and Lukasiewicz's. The last three are their corresponding T-conorms. Aggregators can be defined by the user, see `aggr/1`.

```
faggregator(min).
faggregator(prod).
faggregator(luka).
faggregator(max).
faggregator(dprod).
faggregator(dluka).
```

Usage: `faggregator(Aggr)`

– *Description:* `Aggr` is an aggregator which is cumulative, i.e., its application to several values by iterating pairwise the binary operation is safe.

=>/4: PREDICATE

Usage: `=>(Aggr,A,B,Truth)`

– *Description:* The fuzzy implication `A => B` defined by aggregator `Aggr`, resulting in the truth value `Truth`.

– *The following properties should hold at call time:*

`Aggr` is an aggregator which is cumulative, i.e., its application to several values by iterating pairwise the binary operation is safe. (`user(.../fuzzy_doc):faggregator/1`)

`A` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`B` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`Truth` is a free variable. (`term_typing:var/1`)

98.4 Other information (`fuzzy`)

An example program:

```
:- module(dicesum5,_,[fuzzy]).

% this example tries to measure which is the possibility
% that a couple of values, obtained throwing two loaded dice, sum 5. Let
% us suppose we only know that one die is loaded to obtain a small value
% and the other is loaded to obtain a large value.
%
% the query is  ? sum(5,M)
%

small :# fuzzy_predicate([(1,1),(2,1),(3,0.7),(4,0.3),(5,0),(6,0)]).
large :# fuzzy_predicate([(1,0),(2,0),(3,0.3),(4,0.7),(5,1),(6,1)]).

die1(X,M) :~
        small(X,M).

die2(X,M) :~
        large(X,M).


two_dice(X,Y,M):~ prod
        die1(X,M1),
        die2(Y,M2).

sum(2,M) :~
        two_dice(1,1,M1).


sum(5,M) :~ dprod
        two_dice(4,1,M1),
        two_dice(1,4,M2),
        two_dice(3,2,M3),
        two_dice(2,3,M4).
```

There are more examples in the subdirectory `fuzzy/examples` of the distribution.

98.5 Known bugs and planned improvements (`fuzzy`)

- General aggregations defined by users.
- Inconsistent behaviour of meta-calls in fuzzy clauses.
- Some meta-predicate constructions need be added, specially for 'disjunctive' fuzzy clauses, e.g., `sum/2` in the dice example.

99 Object oriented programming

Author(s): Angel Fernandez Pineda.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.3#63 (1999/9/29, 19:54:17 MEST)

O'Ciao is a set of libraries which allows object-oriented programming in Ciao Prolog. It extends the Ciao Prolog module system by introducing two new concepts:

- Inheritance.
- Instantiation.

Polymorphism is the third fundamental concept provided by object oriented programming. This concept is not mentioned here since **traditional PROLOG systems are polymorphic by nature**.

Classes are declared in the same way as modules. However, they may be enriched with inheritance declarations and other object-oriented constructs. For an overview of the fundamentals of O'Ciao, see `http://www.clip.dia.fi.upm.es/~clip/papers/ociao-tr.ps.gz`. However, we will introduce the concepts in a tutorial way via examples.

99.1 Early examples

The following one is a very simple example which declares a class – a simple stack. Note that if you replace *class/1* declaration with a *module/1* declaration, it will compile correctly, and can be used as a normal Prolog module.

```
%%------------------------------------------------%%
%% A class for stacks.                            %%
%%------------------------------------------------%%

%% Class declaration: the current source defines a class.
:- class(stack,[],[]).

% State declaration: storage/1 is an attribute.
:- dynamic storage/1.

% Interface declaration: the following predicates will
% be available at run-time.
:- export(push/1).
:- export(pop/1).
:- export(top/1).
:- export(is_empty/0).

% Methods

push(Item) :-
        nonvar(Item),
        asserta_fact(storage(Item)).

pop(Item) :-
        var(Item),
        retract_fact(storage(Item)).

top(Top) :-
```

```
        storage(Top), !.

is_empty :-
        storage(_), !, fail.
is_empty.
```

If we load this code at the Ciao toplevel shell:

```
?- use_package(objects).

yes
?- use_class(library('class/examples/stack')).

yes
?-
```

we can create two stack *instances* :

```
?- St1 new stack,St2 new stack.

St1 = stack('9254074093385163'),
St2 = stack('9254074091') ? ,
```

and then, we can operate on them separately:

```
1 ?- St1:push(8),St2:push(9).

St1 = stack('9254074093385163'),
St2 = stack('9254074091') ?

yes
1 ?- St1:top(I),St2:top(K).

I = 8,
K = 9,
St1 = stack('9254074093385163'),
St2 = stack('9254074091') ?

yes
1 ?-
```

The interesting point is that there are two stacks. If the previous example had been a normal module, we would have a stack , but **only one** stack.

The next example introduces the concepts of *inheritable* predicate, *constructor*, *destructor* and *virtual method*. Refer to the following sections for further explanation.

```
%%------------------------------------------%%
%% A generic class for item storage.        %%
%%------------------------------------------%%
:- class(generic).

% Public interface declaration:
:- export([set/1,get/1,callme/0]).

% An attribute
:- data datum/1.
```

```
% Inheritance declaration: datum/1 will be available to
% descendant classes (if any).
:- inheritable(datum/1).

% Attribute initialization: attributes are easily initialized
% by writing clauses for them.
datum(none).

% Methods

set(X) :-
        type_check(X),
        set_fact(datum(X)).

get(X) :-
        datum(X).

callme :-
        a_virtual(IMPL),
        display(IMPL),
        display(' implementation of a_virtual/0 '),
        nl.

% Constructor: in this case, every time an instance
% of this class is created, it will display a message.
generic :-
        display(' generic class constructor '),
        nl.

% Destructor: analogous to the previous constructor,
% it will display a message every time an instance
% of this class is eliminated.
destructor :-
        display(' generic class destructor '),
        nl.

% Predicates:
% cannot be called as messages (X:method)

% Virtual declaration: tells the system to use the most
% descendant implementation of a_virtual/1 when calling
% it from inside this code (see callme/0).
% If there is no descendant implementation for it,
% the one defined bellow will be used.
:- virtual a_virtual/1.

a_virtual(generic).

:- virtual type_check/1.

type_check(X) :-
```

```
        nonvar(X).
```

And the following example, is an extension of previous class. This is performed by establishing an inheritance relationship:

```
%%-----------------------------------------------%%
%% This class provides additional functionality %%
%% to the "generic" class.                       %%
%%-----------------------------------------------%%
:- class(specific).

% Establish an inheritance relationship with class "generic".
:- inherit_class(library('class/examples/generic')).

% Override inherited datum/1.
% datum/1 is said to be overriden because there are both an
% inherited definition (from class "generic") and a local one,
% which overrides the one inherited.
:- data datum/1.
:- inheritable datum/1.

% Extend the public interface inherited from "generic".
% note that set/1 and a_virtual/0 are also overriden.
% undo/0 is a new functionality added.
:- export([set/1,undo/0]).

% Methods

set(Value) :-
        inherited datum(OldValue),
        !,
        inherited set(Value),
        asserta_fact(datum(OldValue)).
set(Value) :-
        inherited set(Value).

undo :-
        retract_fact(datum(Last)), !,
        asserta_fact(inherited(datum(Last))).
undo :-
        retractall_fact(inherited(datum(_))).

% Constructor
specific :-
        generic,
        retractall_fact(inherited(datum(_))),
        display(' specific class constructor '),
        nl.

% Destructor
destructor :-
        display(' specific class destructor '),
```

```
        nl.

% Predicates

% New implementation of a_virtual/1.
% Since this predicate was declared virtual, the
% implementation below will be called from the inherited
% method callme/0 instead of the version defined at "generic".
a_virtual(specific).
```

Additional examples may be found on the *library/class/examples* directory relative to your Ciao Prolog instalation.

99.2 Recommendations on when to use objects

We would like to give some advice in the use of object oriented programming, in conjunction with the declarative paradigm.

You should reconsider using O'Ciao in the following cases:

- The pretended "objects" have no state,i.e., no data or dynamic predicates. In this case, a normal module will suffice.
- There is state, but there will be only one instance of a pretended class. Again, a module suffices.
- The "objects" are data structures (list,trees,etc) already supported by Prolog. However, it does make sense to model, using objects, data structures whose change implies a side-effect such as drawing a particular window on the screen.

We recommend the usage of O'Ciao in the following cases:

- You feel you will need to have several copies of a "module".
- Local copies of a module are needed instead of a global module beeing modified by several ones.
- The "classes" are a representation of external entities to Prolog. For example: the X-Window system.
- There is state or code outside the Prolog system which needs to be manipulated. For example: interfaces to Java or Tcl/Tk code.
- You are not familiar with Prolog, but you know about object oriented programming. O'Ciao may be used as a learning tool to introduce yourself on the declarative programming paradigm.

99.3 Limitations on object usage

O'Ciao run-time speed is limited by the usage of meta-programming structures, for instance: `X = (Object:mymethod(25)), call(X)`. O'Ciao will optimize static manipulation of objects (those that can be determined at compile time).

100 Declaring classes and interfaces

Author(s): Angel Fernandez Pineda.

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O'Ciao classes are declared in the same way as traditional prolog modules. The general mechanism of *source expansion* will translate object-oriented declarations to normal prolog code. This is done transparently to the user.

Abstract *interfaces* are restricted classes which declare exported predicates with no implementation. The implementation itselt will be provided by some class using an `implements/1` declaration. Only `export/1` and `data/1` declarations are allowed when declaring an interface. Normal classes may treated as interfaces just ignoring all exported predicate implementations.

100.1 Usage and interface (`class`)

- **Library usage:**

  To declare a class the compiler must be told to use the `class` *source expansion*. To do so, source code must start with a module declaration which loads the class package:

  ```
  :- class(ClassName).
  ```

  or a `module/3` declaration, as follows:

  ```
  :- module(ClassName,[],[class]).
  ```

  interfaces are declared in a similar way:

  ```
  :- interface(InterfaceName).
  ```

  Please, do not use SICStus-like module declaration, with a non-empty export list. In other case, some non-sense errors will be reported by normal Ciao module system.

  Most of the regular Ciao declarations may be used when defining a class, such as `concurrent/1`, `dynamic/1`, `discontiguous/1`, `multifile/1`, and so on.

  However, there are some restrictions wich apply to those declarations:

  - `meta_predicate/1` declaration is not allowed to hold *addmodule and pred(N) meta-arguments*, except for previously declared multifiles.
  - Attribute and multifile predicates must be declared before any clause of the related predicate.
  - There is no sense in declaring an attribute as meta_predicate.

  It is a good practique to put all your declarations at the very begining of the file, just before the code itself.

- **Exports:**
  - *Predicates:*

    `inherited/1`, `self/1`, `constructor/0`, `destructor/0`.
- **New declarations defined:**

  `export/1`, `public/1`, `inheritable/1`, `data/1`, `dynamic/1`, `concurrent/1`, `inherit_class/1`, `implements/1`, `virtual/1`.
- **Other modules used:**
  - *System library modules:*

    `objects/objects_rt`.

100.2 Documentation on new declarations (`class`)

export/1: DECLARATION

Declares a method or attribute to be part of the *public interface*.

The public interface is the set of predicates wich will be accesible from any code establishing an usage relationship with this class (see `use_class/1` for further information).

Publishing an attribute or method is very similar to *exporting* a predicate in a Prolog module.

Whether an inherited and exported predicate is overriden, it must be explicitly exported again.

An inherited (but not exported) predicate may become exported, without overriding it by the usage of this declaration.

Usage: `:- export(Spec).`

- *Description:* `Spec` will be part of the public (exported) interface.
- *The following properties should hold at call time:*

  `Spec` is a method or attribute specification. (`objects_rt:method_spec/1`)

public/1: DECLARATION

Just an alias for `export/1`.

Usage: `:- public(Spec).`

- *Description:* This declaration may be used instead of `export/1`.
- *The following properties should hold at call time:*

  `Spec` is a method or attribute specification. (`objects_rt:method_spec/1`)

inheritable/1: DECLARATION

Declares a method or attribute to be inherited by descendant classes. Notice that all **public predicates are inheritable by default**. There is no need to mark them as inheritable.

Traditionaly, object oriented languages makes use of the *protected* concept. Inheritable/1 may be used as the same concept.

The set of inheritable predicates is called the *inheritable interface*.

Usage: `:- inheritable(MethodSpec).`

- *Description:* `MethodSpec` is accessible to descendant classes.
- *The following properties should hold at call time:*

  `MethodSpec` is a method or attribute specification. (`objects_rt:method_spec/1`)

data/1: DECLARATION

Declares an *attribute* at current class. Attributes are used to build the internal state of instances. So, each instance will own a particular copy of those attribute definitions. In this way, one instance may have different state from another.

O'Ciao attributes are restricted to hold simple facts. It is not possible to hold a Head :- Body clause at an instance attribute.

Notice that attributes are *multi-evaluated* by nature, and may be manipulated by the habitual **assert/retract** family of predicates.

Attributes may also be initialized. In order to do so, simply put some clauses after the attribute definition. Each time an instance is created, its initial state will be built from those *initialization clauses*.

Note: whether a data/1 declaration appears inside an interface, it will be automatically exported.

Usage: :- `data Spec`.

- *Description:* `Spec` is an attribute.
- *The following properties should hold at call time:*

  `Spec` is a method or attribute specification. (`objects_rt:method_spec/1`)

dynamic/1: DECLARATION

Just an alias for `data/1`.

Usage: :- `dynamic Spec`.

- *Description:* You may use this declaration instead of `data/1`.
- *The following properties should hold at call time:*

  `Spec` is a method or attribute specification. (`objects_rt:method_spec/1`)

concurrent/1: DECLARATION

Declares a *concurrent attribute* at current class. Concurrent attributes are just the same as normal attributes, those declared using `data/1`, except for they may freeze the calling thread instead of failing when no more choice points are remaining on the concurrent attribute.

In order to get more information about concurrent behavior take a look to the concurrent/1 built-in declaration on Ciao Prolog module system.

Usage: :- `concurrent Spec`.

- *Description:* Declares `Spec` to be a concurrent attribute.
- *The following properties should hold at call time:*

  `Spec` is a method or attribute specification. (`objects_rt:method_spec/1`)

inherit_class/1: DECLARATION

Makes any public and/or inheritable predicate at inherited class to become accesible by any instance derived from current class.

Inherited class is also called the *super class*.

Only one inherit_class/1 declaration is allowed to be present at current source.

Notice that inheritance is public by default. Any public and/or inheritable declaration will remain the same to descendant classes. However, any inherited predicate may be *overriden* (redefined).

A predicate is said to be *overriden* when it has been inherited from super class, but there are clauses (or a `data/1` declaration) present at current class for such a predicate.

Whether a **public** predicate is overriden, the local definition must also be exported, otherwise an error is reported.

Whether an **inheritable** predicate (not public) is overriden, the local definition must also be marked as inheritable or exported, otherwise an error is also reported.

Note: whether inherit_class/1 appears inside an interface, it will be used as an `implements/1` declaration.

Usage: :- `inherit_class(Source)`.

- *Description:* Establish an *inheritance relationship* between current class and the class defined at `Source` file.
- *The following properties should hold at call time:*

  `Source` is a valid path to a prolog file containing a class declaration (without .pl extension). (`objects_rt:class_source/1`)

implements/1: DECLARATION

Forces current source to provide an implementation for the given interface file. Such interface file may declare another class or a specific interface.

Every public predicate present at given interface file will be automatically declared as public at current source, so you **must** provide an implementation for such predicates.

The effect of this declaration is called *interface inheritance*,and there is no restriction on the number of implements/1 declarations present at current code.

Usage: `:- implements(Interface).`

- *Description:* Current source is supposed to provide an implementation for `Interface`.
- *The following properties should hold at call time:*

  `Interface` is a valid path to a prolog file containing a class declaration or an interface declaration (without .pl extension). (`objects_rt:interface_source/1`)

virtual/1: DECLARATION

This declaration may be used whenever descendant classes are to implement different versions of a given predicate.

virtual predicates give a chance to handle, in an uniform way, different implementations of the same functionality.

Whether a virtual predicate is declared as a method, there must be at least one clause of it present at current source. Whenever no special implementation is needed at current class, a never-fail/allways-fail clause may be defined (depending on your needs). For example:

```
:- virtual([ test1/1 , test2/2 ]).
test1(_).
test2(_,_) :- fail.
```

This kind of virtual methods are also known as *abstract methods*, since implementation is fully delegated to descendant classes.

An attribute may be also declared as a virtual one, but there is no need to write clauses for it.

Usage: `:- virtual(VirtualMethodSpec).`

- *Description:* All calls to `VirtualMethodSpec` predicate in current source will use the most descendant implementation of it.
- *The following properties should hold at call time:*

  `VirtualMethodSpec` is a method specification. (`objects_rt:virtual_method_spec/1`)

100.3 Documentation on exports (`class`)

inherited/1: PREDICATE

This predicate qualificator may be used whenever you need to reference an attribute or method on the super class.

Since methods and attributes may be redefined, this qualificator is need to distinguish between a locally declared predicate and the inherited one, which has the same name.

There is no need to use inherited/1 if a particular inherited predicate has not been redefined at current class.

Usage: `inherited(Goal)`

- *Description:* References a given `Goal` at the super class
- *The following properties should hold at call time:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

self/1: PREDICATE

Determines which instance is currently executing self/1 goal.

Predicate will fail if argument is not a free variable. Otherwise, it will allways succeed, retrieving the instance identifier which is executing current code.

This functionality is very usefull since an object must have knowledge of other object's identifier in order to send messages to it.For example:

:- concurrent ack/0.

send_data_to_object(Data,Obj) :- self(X), Obj:take_this(Data,X), current_fact(ack).

acknowledge :- asserta_fact(ack).

take_this(Data,Sender) :- validate_data(Data), Sender:acknowledge.

Usage: `self(Variable)`

- *Description:* Retrieves current instance identifier in `Variable`
- *The following properties should hold at call time:*

  `Variable` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*

  `Variable` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

constructor/0: PREDICATE

A *constructor* is a special case of method which complains the following conditions:

- The constructor functor matches the current class name.
- A constructor may hold any number of arguments.
- If an inheritance relationship was defined, an inherited constructor must be manually called (see below).
- When instance creation takes place, any of the declared constructors are implicitly called. The actual constructor called depends on the `new/2` goal specified by the user.

This is a simple example of constructor declaration for the foo class:

```
foo :-
    display('an instance was born').
```

Constructor declaration is not mandatory, and there may be more than one constructor declarations (with different arity) at the source code.

This functionality is usefull when some computation is needed at instance creation. For example: opening a socket, clearing the screen, etc.

Whenever an inheritance relationship is established, and there is any constructor defined at the super class, you must call manually an inherited constructor. Here is an example:

```
:- class(foo).
:- inherit_class(myclass).

foo :-
    myclass(0),
    display('an instance was born').

foo(N) :- myclass(N).
```

Consequences may be unpredictable, if you forget to call an inherited constructor. You should also take care not to call an inherited constructor twice.

All defined constructors are inheritable by default. A constructor may also be declared as public (by the user), but it is not mandatory.

Usage:

– *Description:* Constructors are implicitly declared

destructor/0: PREDICATE

A *destructor* is a special case of method which will be automatically called when instance destruction takes place.

A destructor will never be wanted to be part of the public interface, and there is no need to mark them as inheritable, since all inherited destructors are called by O'Ciao just before yours.

This is a simple example of destructor declaration:

```
destructor :-
    display('goodbye, cruel world!!!').
```

Destructor declaration is not mandatory. Failure or sucess of destructors will be ignored by O'Ciao, and they will be called only once.

This functionality is useful when some computation is need at instance destruction. For example: closing an open file.

Usage:

– *Description:* Destructors are implicitly declared

100.4 Other information (class)

This describes the errors reported when declaring a class or an interface. The first section will explain compile-time errors, this is, any semantic error which may be determined at compile time. The second section will explain run-time errors, this is, any exception that may be raisen by the incorrect usage of O'Ciao. Some of those errors may be not reported at compile time, due to the use of meta-programational structures. For example:

```
functor(X,my_method,0),call(X).
```

O'Ciao is not able to check whether my_method/0 is a valid method or not. So, this kind of checking is left to run time.

100.4.1 Class and Interface error reporting at compile time

- **ERROR : multiple inheritance not allowed.**

  There are two or more inherit_class/1 declarations found at your code. Only one declaration is allowed, since there is no multiple code inheritance support.

- **ERROR : invalid inheritance declaration.**

  The given parameter to inherit_class/1 declaration is not a valid path to a Prolog source.

- **ERROR : sorry, addmodule meta-arg is not allowed at** *F/A*.

  You are trying to declare *F/A* as meta-predicate, and one of the meta-arguments is *addmodule*. This is not allowed in O'Ciao due to implementation restrictions. For example:

  ```
  :- meta_predicate example(addmodule).

  example(X,FromModule) :- call(FromModule:X).
  ```

- **ERROR : invalid attribute declaration for** *Arg*.

  Argument to data/1 or dynamic/1 declaration is not a valid predicate specification of the form *Functor/Arity*. For example:

  ```
  :- data attr.

  :- dynamic attr(_).

  :- data attr/m.
  ```

  etc,etc...

- **ERROR : pretended attribute** *F/A* **was assumed to be a method.**

  You put some clauses of *F/A* before the corresponding data/1 or dynamic/1 declaration. For example:

  ```
  attr(initial_value).

  :- data attr/1.
  ```

  It is a must to declare attributes before any clause of the given predicate.

- **ERROR : destructor/0 is not allowed to be an attribute.**

  There is a :- data(destructor/0) or :- dynamic(destructor/0). declaration in your code. This is not allowed since destructor/0 is a reserved predicate, and must be allways a method.

- **ERROR :** *Constructor* **is not allowed to be an attribute.**

  As the previos error, you are trying to declare a constructor as an attribute. A constructor must be allways a method.

- **ERROR : invalid multifile: destructor/0 is a reserved predicate.**

  There is a :- multifile(destructor/0). declaration in your code. This is not allowed since destructor/0 is a reserved predicate, and must be allways a method.

- **ERROR : invalid multifile:** *Constructor* **is a reserved predicate.**

  As the previos error, you are trying to declare a constructor as a multifile. Any constructor must allways be a method.

- **ERROR : multifile declaration of** *F/A* **ignored: it was assumed to be a method.**

  You put some clauses of *F/A* before the corresponding multifile/1 declaration. For example:

  example(a,b).

  ```
  :- multifile example/2.
  ```

  Multifile predicates must be declared before any clause of the given predicate.

- **ERROR : invalid multifile declaration: multifile(***Arg***).**

  Given argument to multifile/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.

- **ERROR : invalid public declaration:** *Arg*.
  Given argument *Arg* to public/1 or export/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.
- **ERROR : invalid inheritable declaration: inheritable(***Arg***).**
  Given argument *Arg* to inheritable/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.
- **ERROR : destructor/0 is not allowed to be virtual.**
  There is a :- virtual(destructor/0) declaration present at your code. Destructors and/or constructors are not allowed to be virtual.
- **ERROR :** *Constructor* **is not allowed to be virtual.**
  As the previous error, you are trying to declare a constructor as virtual. This is not allowed.
- **ERROR : invalid virtual declaration: virtual(***Arg***).**
  Given argument to virtual/1 declaration is not a valid predicate specification, of the form *Functor/Arity*.
- **ERROR : clause of** *F/A* **ignored : only facts are allowed as initial state.**
  You declared *F/A* as an attribute, then you put some clauses of that predicate in the form *Head :- Body*. For example:
  ```
  :- data my_attribute/1.
  my_attribute(X) :- X>=0 , X<=2.
  ```
  This is not allowed since attributes are assumed to hold simple facts. The correct usage for those *initialization clauses* is:
  ```
  :- data my_attribute/1.
  my_attribute(0).
  my_attribute(1).
  my_attribute(2).
  ```
- **ERROR : multifile** *F/A* **is not allowed to be public.**
  The given *F/A* predicate is both present at multifile/1 and public/1 declarations. For example:
  ```
  :- public(p/1).
  :- multifile(p/1).
  ```
  This is not allowed since multifile predicates are not related to Object Oriented Programming.
- **ERROR : multifile** *F/A* **is not allowed to be inheritable.**
  Analogous to previous error.
- **ERROR : multifile** *F/A* **is not allowed to be virtual.**
  Analogous to previous error.
- **ERROR : virtual** *F/A* **must be a method or attribute defined at this class.**
  There is a virtual/1 declaration for *F/A*, but there is not any clause of that predicate nor a `data/1` declaration. You must declare at least one clause for every virtual method. Virtual attributes does not require any clause but a `data/1` declaration must be present.
- **ERROR : implemented interface** *Module* **is not a valid interface.**
  There is an `implements/1` declaration present at your code where given *Module* is not declared as class nor interface.
- **ERROR : predicate** *F/A* **is required both as method (at** *Itf1* **interface) and attribute (at** *Itf2* **interface).**
  There is no chance to give a correct implementation for *F/A* predicate since *Itf1* and *Itf2* interfaces require different definitions. To avoid this error, you must remove one of the related `implements/1` declaration.

- **ERROR : inherited *Source* must be a class.**

  There is an :- inherit_class(*Source*) declaration, but that source was not declared as a class.
- **ERROR : circular inheritance: *Source* is not a valid super-class.**

  Establishing an inheritance relationship with *Source* will cause current class to be present twice in the inheritance line. This is not allowed. The cause of this is error is simple : There is some inherited class from *Source* which also establishes an inheritance relationship with current source.
- **ERROR : method/attribute *F/A* must be implemented.**

  Some of the implemented interfaces requires *F/A* to be defined, but there is no definition for such predicate, even an inherited one.
- **ERROR : local implementation of *F/A* hides inheritable/public definition.**

  There is an inherited definition for *F/A* which is been redefined at current class, but there is no valid inheritable/public declaration for the last one. Overriden public predicates must be also declared as public. Overriden inheritable predicates must be declared either as public or inheritable.
- **ERROR : public predicate *F/A* was not defined nor inherited.**

  There is a `public/1` declaration for *F/A*, but there is no definition for it at current class nor an inherited one.
- **ERROR : argument to self/1 must be a free variable.**

  Argument to self/1 is not a variable, for example: `self(abc)`.
- **ERROR : unknown inherited attribute in *Goal*.**

  Goal belongs to assert/retract family of predicates, and given argument is not a valid inherited attribute. The most probable causes of this error are:
  - The given predicate is defined at super-class, but you forgot to mark it as inheritable (or public), at such class.
  - The given predicate was not defined (at super-class) as an attribute, just as a method.
- **ERROR : unknown inherited goal: *Goal*.**

  The given *Goal* was not found at super-class, or it is not accessible. Check whether *Goal* was marked as inheritable (or public) at super-class.
- **ERROR : invalid argument: *F/A* is not an attribute.**

  You are trying to pass a method as an argument to any predicate which expect a *fact* predicate.
- **ERROR : unknown inherited fact: *Fact*.**

  There is a call to any predicate which expects a *fact* argument (those declared as data or dynamic),but the actual argument is not an inherited attribute.For example:

  ```
  asserta_fact(inherited(not_an_attribute(8)))
  ```

  where not_an_attribute/1 was not declared as data or dynamic by the super-class (or corresponding ascendant).
- **ERROR : unknown inherited spec: *F/A*.**

  There is a reference to an inherited predicate specification, but the involved predicate has not been inherited.
- **WARNING : meta-predicate specification of *F/A* ignored since this is an attribute.**

  You declared *F/A* both as an attribute and a meta-predicate. For example:

  ```
  :- meta_predicate attr(goal).
  :- data attr/1.
  ```

  There is no sense in declaring an attribute as meta-predicate.

- **WARNING : class destructor is public**

  There is a :- public(destructor/0) declaration present at your code. Marking a destructor as public is a very bad idea since anybody may destroy or corrupt an instance before the proper time.
- **WARNING : class destructor is inheritable**

  Analogous to previous error.
- **WARNING : There is no call to inherited constructor/s**

  You have not declared any constructor at your class, but there is any inherited constructor that should be called. Whenever you do not need constructors, but there is an inheritance relationship (where super-class declares a constructor), you should write a simple constructor as the following example:

```
:- class(myclass).
:- inherit_class(other_class).

myclass :-
        other_class.
```

- **WARNING : multifile *F/A* hides inherited predicate.**

  You declared as multifile a predicate which matches an inherited predicate name. Any reference to the inherited predicate must be done by the ways of the inherited/1 qualificator.

100.4.2 Class and Interface error reporting at run time

- **EXCEPTION : error(existence_error(object_goal,*Goal*),*Mod*).**

  Called *Goal* from module (or class) *Mod* is unknown or has not been published.

100.4.3 Normal Prolog module system interaction

O'Ciao works in conjunction with the Ciao Prolog module system, which also reports its own error messages. This will cause Ciao to report a little criptic error messages due to the general mechanism of source-to-source expansion. Those are some tips you must consider when compiling a class:

- Any error relative to method 'm' with arity A will be reported for predicate 'obj$m'/A+1. For example :

  `WARNING: (lns 28-30) [Item,Itema] - singleton variables in obj$remove/2`

  This error is relative to method remove/1.
- `set_prolog_flag/1` declaration will be usefull when declaring multiple constructors. It will avoid some awful warnings. Example:

```
:- class(myclass).

%% Use this declaration whenever several constructors are needed.

:- set_prolog_flag(multi_arity_warnings,off).

myclass(_).

myclass(_,_).

:- set_prolog_flag(multi_arity_warnings,on).
```

100.5 Known bugs and planned improvements (`class`)

- addmodule and pred(N) meta-arguments are not allowed on meta-predicates.

101 Compile-time usage of objects

Author(s): Angel Fernandez Pineda.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#32 (2000/11/14, 13:13:15 CET)

This package is required to enable user code to create objects and manipulate them, as well as loading any needed class.

101.1 Usage and interface (objects)

- **Library usage:**

  Any code which needs to use objects must include the objects package:

  ```
  :- module(ModuleName,Exports,[objects]).
  ```

  You can use objects even if your code is a class. Note that declaring a class does not automatically enables the code to create instances.

  ```
  :- class(ModuleName,[],[objects]).
  ```

  This package enables both static and dynamic usage of objects.
- **New declarations defined:**

  `use_class/1`, `instance_of/2`, `new/2`.
- **Other modules used:**
  - *System library modules:*

    `objects/objects_rt`.

101.2 Documentation on new declarations (objects)

use_class/1: DECLARATION

It establishes an usage relationship between the given file (which is supposed to declare a class) and current source. Usage relationships are needed in order to enable code to create instances of the given class, and to make calls to instances derived from such class.

Since an interface is some kind of class, they may be used within this declaration but only for semantic checking porpouses. Instances will not be derived from interfaces.

use_class/1 is used in the same way as `use_module/1`.

Usage: `:- use_class(ClassSource).`

- *Description:* Establish usage relationship with `ClassSource`.
- *The following properties should hold at call time:*

  `ClassSource` is a valid path to a prolog file containing a class declaration (without .pl extension). (`objects_rt:class_source/1`)

instance_of/2: DECLARATION

Statically declares an identifier to be an instance of a given class.

It may be used as `new/2` predicate except for:

- The instance identifier will not be a variable, it must be provided by the user, and must be unique.
- Instance creation will never fail, even if the constructor fails.

For every statically declared object the given constructor will be called at program startup. Those instances may be destroyed manually, but it is not recommended.

When reloading the involved class from the Ciao toplevel shell. It may destroy statically declared instances, and create them again.

Statically declared instances must be called using a specifically designed module-qualification: `ClassName(Object):Goal`. For example:

```
:- module(example,[main/0],[objects]).
:- use_class(library(counter)).
:- cnt instance_of counter(10).

main :-
     counter(cnt):decrease(1),
     counter(cnt):current_value(X),
     display(X).
```

But **statically written code** (only) is allowed to use module-style qualifications as a macro:

```
main :-
     cnt:decrease(1),
     cnt:current_value(X),
     display(X).
```

Notice that dynamically expanded goals such as `X=cnt,X:decrease(1)` will not work, use `X=counter(cnt),X:decrease(1)` instead.

Usage: `:- instance_of(Object,Constructor).`

- *Description:* Declares `Object` to be an instance of the class denoted by `Constructor`.
- *The following properties should hold at call time:*

  `Object` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

  `Constructor` is a term whose functor matches a class name. (`objects_rt:constructor/1`)

new/2: DECLARATION

This declaration has the same effect as `instance_of/2`.

Usage: `:- new(Object,Constructor).`

- *Description:* Just an alias for `instance_of/2`.
- *The following properties should hold at call time:*

  `Object` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

  `Constructor` is a term whose functor matches a class name. (`objects_rt:constructor/1`)

101.3 Other information (`objects`)

Compile-time errors are restricted to some local analysis. Since there is no type declaration in the Prolog language, there is no posibility to determine whenever a given variable will hold an instance of any class.

However, little semantic analysis is performed. User may aid to perform such an analysis by the usage of run time checks (which are also detected at compile time), or static declarations. For example:

```
clause(Obj) :- Obj:a_method(334).
```

O'Ciao may be not able to determine whenever a_method/1 is a valid method for instance Obj, unless some help is provided:

```
clause(Obj) :- Obj instance_of myclass,Obj:a_method(334).
```

In such case, O'Ciao will report any semantic error at compile-time.

Most of the run-time errors are related to normal Ciao Prolog module system. Since objects are treated as normal Prolog modules at run time, there is no further documentation here about that stuff.

101.3.1 Error reporting at compile time (objects)

- **ERROR : invalid instance identifier** *ID*: **must be an atom**

  There is a `instance_of/2` or `new/2` declaration where first argument *ID* must be an unique atom, but currently it is not. Statically declared instances needs an identifier to be provided by the user.
- **ERROR : instance identifier** *ID* **already in use**

  There are two or more `instance_of/2` declarations with the same first argument *ID*. Instance identifiers must be unique.
- **ERROR : invalid use_class/1 declaration:** *SourceFile* **is not a class**

  Those are the causes for this error:
  - The given *SourceFile* does not exist, or is not accesible.
  - The given *SourceFile* is not a Prolog source.
  - The given *SourceFile* is a valid Prolog source, but it does not declare a class.
- **ERROR : unknown class on** *ID* **instance declaration**

  The class defined on the `instance_of/2` declaration for *ID* instance has not been loaded by a `use_class/1` declaration.
- **ERROR : instance identifier** *ID* **is an exisisting Prolog module**

  There is an statically declared instance whose identifier may cause interference with the Ciao Prolog module system. Use another instance identifier.
- **ERROR : unknown constructor on** *ID* **instance declaration**

  The given constructor on the `instance_of/2` declaration for *ID* has not been defined at the corresponding class.
- **ERROR : constructor is needed on** *ID* **instance declaration**

  No constructor was defined on the `instance_of/2` declaration for *ID* and default constructor is not allowed. You must provide a constructor.
- **ERROR : static instance** *ID* **was derived from a different constructor at** *AnotherModule*

  ID has been declared to be an static instance both on *AnotherModule* and current source, but different constructors were used. The most probable causes for this error are:
  - Occasionally, there is another module using the same instance identifier and it was not noticed by you. Another different identifier may be used instead.
  - It was you intention to use the same object as declared by the other module. In this case, the same constructor must be used.
- **ERROR : invalid first argument in call to new(**_Arg_**,_)**

  There is a new/1 goal in your code where first argument is not a free variable. For example:

`myobj new myclass`

First argument must be a variable in order to receive a run-time generated object identifier.

- **ERROR : unknown class in call to new(?,*Constructor*)**

  The given *Constructor* in call to new/2 does not correspond to any used class at current code. The most probable cause of this may be:

  - You forgot to include a `use_class/1` declaration in your code.
  - There is a spelling mistake in the constructor.For example:

    :- use_class(myclass).

    foo(X) :- X new mclass.

- **ERROR : can not create an instance from an interface: new(?,*Constructor*)**

  Given *Constructor* references an interface rather than a class. Instances can not be derived from interface-expanded code.

- **ERROR : unknown constructor in call to new(?,*Constructor*)**

  As the previous error, there is a mistake in the given *Constructor*. This error is reported when you are trying to call a constructor which was not defined at the corresponding class. Check the class definition to find what is going on.

  Another cause for this error is the incorrect usage of the default constructor. Whenever there are one or more constructors defined at the involved class, you are restricted to chose one of them. This seems that default constructor will be available, if and only if, there are no constructors defined at the involved class.

- **ERROR : call to non-public** *ID:Goal*

  You are trying to call a method which was not declared as public by the class specified in `instance_of/2` declaration for *ID*.

- **ERROR : call to inaccessible predicate at instance** *ID:Goal*

  There is a call to *Goal* at statically declared instance *ID* which is unknown or was not declared as public.

- **ERROR : unknown instance** *ID* **of class** *Class* **at** *Goal*

  There is a call to *Goal* where involved statically declared instance *ID* is unknown or is not derived from *Class*. Check whether it was declared by a `instance_of/2` declaration.

- **ERROR : inaccessible attribute** *Fact* **at instance** *ID*

  There is an attempt to use *ID:Fact* but it was not declared as public.

- **ERROR : unknown attribute** *Fact* **at instance** *ID*

  There is an attempt to use *ID:Fact* but it is unknown or it is not an attribute (may be a method).

- **WARNING : invalid call to new(?,_)**

  There is a call to new/2 in you code where first argument variable has been determined to hold any other instance. For example:

  `foo :- X new myclass,X new otherclass.`

  or

  `foo(X) :- X instance_of myclass, X new myclass.`

  The related call to new/2 will allways fail.

- **WARNING : called** *Goal* **is not public at any used class**

  There is a call to *Var*:*Goal* where *Var* has not been determined to be compatible with any class. However, *Goal* is not public at any class specified by the `use_class/1` declaration.

  This is a warning (not an error) since *Var*:*Goal* may be not related to Object Oriented Programing.

101.3.2 Error reporting at run time (objects)

- **EXCEPTION : instantiation_error('1st argument must be free variable')**
  Calling to new/1 requieres first argument to be a free variable. For example:
  `X = this_will_raise_an_exception,X new myclass.`
- **EXCEPTION : instantiation_error('class not given')**
  You called new/2 using a free variable as second argument.
- **EXCEPTION : instantiation_error(inaccesible_class(***Class***), from(***Module***))**
  Module tried to create an instance of *Class* by the ways of new/2, but there is no usage relationship between *Module* and *Class*.
- **EXCEPTION : instantiation_error(invalid_constructor(** *Constructor***))**
  Constructor was not defined by the corresponding class.

102 Run time usage of objects

Author(s): Angel Fernandez Pineda, Angel Fernandez Pineda.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#51 (2001/1/25, 21:33:0 CET)

This library provides run-time support for object creation and manipulation. Objects are also called class instances, or simply instances.

Objects in Ciao are treated as normal modules. This is, an object is a run-time generated Prolog module, which may be identified by an unique term across the whole application.

This is a very simple example of how to create an instance, and how to make calls to it:

```
AnObj new myclass,
AnObj:mymethod.
```

In order to make any object accessible from code, an usage relationship must be established between the class (from which instances are derived) and the code itself. Refer to `use_class/1` predicate or `use_class/1` declaration in order to do so.

102.1 Usage and interface (`objects_rt`)

- **Library usage:**

  This library is automatically loaded when using the *objects* package:

  ```
  :- module(ModuleName,Exports,[objects]).
  ```

  Nothing special needs to be done.
- **Exports:**
  - *Predicates:*

    `new/2`, `instance_of/2`, `derived_from/2`, `interface/2`, `instance_codes/2`, `destroy/1`, `use_class/1`.
  - *Properties:*

    `constructor/1`, `class_name/1`, `interface_name/1`, `instance_id/1`, `class_source/1`, `interface_source/1`, `method_spec/1`, `virtual_method_spec/1`.
- **Other modules used:**
  - *System library modules:*

    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `compiler/compiler`, `prolog_sys`, `system`.

102.2 Documentation on exports (`objects_rt`)

new/2: PREDICATE

Dynamic instance creation takes place by the ways of this predicate.

It takes a free variable as first argument which will be instantiated to an internal object identifier.

Second argument must be instantiated to a class constructor. Class constructors are designed to perform an initialization on the new created instance. Notice that instance initialization may involve some kind of computation, not only *state initialization*.

A class constructor is made by a functor, which must match the intended class name, and any number of parameters. For example:

```
Obj new myclass(1500,'hello, world!!!')
```

Those parameters depends (obviously) on the constructors defined at the class source. If no constructors where defined, no parameters are needed. This is called the default constructor. An example:

```
Obj new myclass
```

The default constructor can not be called if there is any constructor available at the class source.

Instantiation will raise an exception and fail whenever any of this conditions occur:

- First argument is not a free variable.
- Second argument functor is a class, but there is no usage relationship with it.
- Second argument functor is not a class.
- The given constructor is unknown.
- The given constructor fails (notice that default constructor never fails).

Objects may also be statically declared, refer to `instance_of/2` declaration.

Usage: `new(InstanceVar,Constructor)`

- *Description:* Creates a new instance of the class specified by `Constructor` returning its identifier in `InstanceVar`
- *The following properties should hold at call time:*

  `InstanceVar` is a free variable. (`term_typing:var/1`)

  `Constructor` is a term whose functor matches a class name. (`objects_rt:constructor/1`)
- *The following properties should hold upon exit:*

  `InstanceVar` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

instance_of/2: PREDICATE

This predicate is used to perform dynamic type checking. You may check whether a particular instance belongs to a particular class or related descendants.

instance_of/2 is used to perform static semantic analisys over object oriented code constructions.

By the use of instance_of/2 you may help to perform such analisys.

Usage 1: `instance_of(Instance,Class)`

- *Description:* Test whether `Instance` was derived from any descendant of `Class`, or that class itself
- *The following properties should hold at call time:*

  `Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

  `Class` is an atom denoting a class. (`objects_rt:class_name/1`)

Usage 2: `instance_of(Instance,Class)`

- *Description:* Retrieves, on backtracking, the inheritance line of `Instance` commencing on the creation class (that specified on call to `new/2`) and continuing on the rest of ascendant classes, if any.

– *The following properties should hold at call time:*

`Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

`Class` is a free variable. (`term_typing:var/1`)

– *The following properties should hold upon exit:*

`Class` is an atom denoting a class. (`objects_rt:class_name/1`)

derived_from/2: PREDICATE

Test whether an object identifier was derived directly from a class, by the usage of `new/2` or a static instance declaration (`instance_of/2`).

Usage 1: `derived_from(Instance,Class)`

– *Description:* Test derivation of `Instance` from `Class`

– *The following properties should hold at call time:*

`Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

`Class` is an atom denoting a class. (`objects_rt:class_name/1`)

Usage 2: `derived_from(Instance,Class)`

– *Description:* Retrieves the `Class` responsable of the derivation of `Instance`.

– *The following properties should hold at call time:*

`Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

`Class` is a free variable. (`term_typing:var/1`)

– *The following properties should hold upon exit:*

`Class` is an atom denoting a class. (`objects_rt:class_name/1`)

interface/2: PREDICATE

This predicate is used to ensure a given interface to be implemented by a given instance.

Usage 1: `interface(Instance,Interface)`

– *Description:* Check whether `Instance` implements the given `Interface`.

– *The following properties should hold at call time:*

`Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

`Interface` is an unique atom which identifies a public interface. (`objects_rt:interface_name/1`)

Usage 2: `interface(Instance,Interfaces)`

– *Description:* Retrieves on backtracking all the implemented `Interfaces` of `Instance`.

– *The following properties should hold at call time:*

`Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

`Interfaces` is a free variable. (`term_typing:var/1`)

– *The following properties should hold upon exit:*

`Interfaces` is an unique atom which identifies a public interface. (`objects_rt:interface_name/1`)

instance_codes/2: PREDICATE

Retrieves a character string representation from an object identifier and vice-versa.

Usage 1: `instance_codes(Instance,String)`

- *Description:* Retrieves a `String` representation of given `Instance`.
- *The following properties should hold at call time:*

  `Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

  `String` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*

  `String` is a string (a list of character codes). (`basic_props:string/1`)

Usage 2: `instance_codes(Instance,String)`

- *Description:* Reproduces an `Instance` from its `String` representation. Such an instance must be alive across the application: this predicate will fail whether the involved instance has been destroyed.
- *The following properties should hold at call time:*

  `Instance` is a free variable. (`term_typing:var/1`)

  `String` is a string (a list of character codes). (`basic_props:string/1`)
- *The following properties should hold upon exit:*

  `Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

destroy/1: PREDICATE

As well as instances are created, they must be destroyed when no longer needed in order to release system resources.

Unfortunately, current O'Ciao implementation does not support automatic instance destruction, so user must manually call *destroy/1* in order to do so.

The programmer **must ensure** that no other references to the involved object are left in memory when destroy/1 is called. If not, unexpected results may be obtained.

Usage: `destroy(Instance)`

- *Description:* Destroys the object identified by `Instance`.
- *The following properties should hold at call time:*

  `Instance` is an unique term which identifies an object. (`objects_rt:instance_id/1`)

use_class/1: PREDICATE

The behaviour of this predicate is identical to that provided by the declaration of the same name `use_class/1`. It allows user programs to dynamically load classes. Whether the given source is not a class it will perform a `use_module/1` predicate call.

Usage: `use_class(ClassSource)`

- *Description:* Dynamically loads the given `ClassSource`
- *The following properties should hold at call time:*

  `ClassSource` is a valid path to a prolog file containing a class declaration (without .pl extension). (`objects_rt:class_source/1`)

constructor/1: PROPERTY

Usage: `constructor(Cons)`

– *Description:* `Cons` is a term whose functor matches a class name.

class_name/1: PROPERTY

Usage: `class_name(ClassName)`

– *Description:* `ClassName` is an atom denoting a class.

interface_name/1: PROPERTY

Usage: `interface_name(Interface)`

– *Description:* `Interface` is an unique atom which identifies a public interface.

instance_id/1: PROPERTY

Usage: `instance_id(ID)`

– *Description:* `ID` is an unique term which identifies an object.

class_source/1: PROPERTY

Usage: `class_source(Source)`

– *Description:* `Source` is a valid path to a prolog file containing a class declaration (without .pl extension).

interface_source/1: PROPERTY

Usage: `interface_source(Source)`

– *Description:* `Source` is a valid path to a prolog file containing a class declaration or an interface declaration (without .pl extension).

method_spec/1: PROPERTY

There is no difference between method or attribute specifications, and habitual predicate specifications. It is just a Functor/Arity term.

Usage: `method_spec(Spec)`

– *Description:* `Spec` is a method or attribute specification.

virtual_method_spec/1: PROPERTY

Usage: `virtual_method_spec(Spec)`

– *Description:* `Spec` is a method specification.

102.3 Known bugs and planned improvements (`objects_rt`)

- Usage of objects from the `user` module does not work properly. It is better to use the `objects` package in a (proper) module.
- Not really a bug: when loading code which declares static instances from the toplevel shell, predicate `use_module/1`) will not work properly: those instances may be not correctly created, and predicates will fail whenever they are not supposed to do. This may be avoided by reloading again the involved module, but make sure it is modified and saved to disk before doing so.

103 The Ciao Remote Services Package

Author(s): Manuel Carro.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#17 (2000/9/11, 16:58:15 CEST)

103.1 Usage and interface (`remote`)

- **Library usage:**
  `:- use_module(library(remote)).`
- **Other modules used:**
  - *System library modules:*
    `remote/ciao_client_rt`.

103.2 Documentation on exports (`remote`)

`@/2`: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

`@/2`: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

server_stop/1: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

server_stop/1: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

server_trace/1: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

server_trace/1: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

server_notrace/1: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

server_notrace/1: (UNDOC_REEXPORT)
Imported from `ciao_client_rt` (see the corresponding documentation for details).

103.3 Known bugs and planned improvements (`remote`)

- Dynamic loading of code not yet implemented.
- :- remote/1 predicate declaration not yet implemented.
- Remote use of modules (http, ftp, ciaotp) not yet implemented.
- Remote creation of objects not yet implemented.
- Code migration not yet implemented (several algorithms possible).
- Evaluation of impact of marshalling and/or attribute encoding not yet done.
- Secure transactions not yet implemented.

PART VIII - Interfaces to other languages and systems

The following interfaces to/from Ciao Prolog are documented in this part:

- External interface (e.g., to C).
- Socket interface.
- Tcl/tk interface.
- Web interface (http, html, xml, etc.);
- Persistent predicate databases (interface between the Prolog internal database and the external file system).
- SQL-like database interface (interface between the Prolog internal database and external SQL/ODBC systems).
- Java interface.
- Calling emacs from Prolog.

104 Foreign Language Interface

Author(s): Jose Morales, Manuel Carro.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#206 (2002/4/22, 21:0:27 CEST)

Ciao Prolog includes a high-level, flexible way to interface C and Prolog, based on the use of assertions to declare what are the expected types and modes of the arguments of a Prolog predicate, and which C files contain the corresponding code. To this end, the user provides:

- A set of C files, or a precompiled shared library,
- A Ciao Prolog module defining whith predicates are implemented in the C files and the types and modes of their arguments, and
- an (optional) set of flags required for the compilation of the files.

The Ciao Prolog compiler analyzes the Prolog code written by the user and gathers this information in order to generate automatically C "glue" code implementing the data translation between Prolog and C, and to compile the C code into dynamically loadable C object files, which are linked automatically when needed.

104.1 Declaration of Types

Each predicate implemented as a foreign C function must have accompanying declarations in the Ciao Prolog associated file stating the types and modes of the C function. A sample declaration for `prolog_predicate` which is implemented as `foreign_function_name` is:

```
:- true pred prolog_predicate(m1(Arg1), ... mN(ArgN)) ::
              type1 * ... * typeN +
              (foreign(foreign_function_name), returns(ArgR)).

:- impl_defined([..., prolog_predicate/N, ...]).
```

where `m1`, ..., `mN` and `type1`, ..., `typeN` are respectively the modes and types of the arguments. `foreign_function_name` is the name of the C function implementing `prolog_predicate/N`, and the result of this function is unified with `ArgR`, which must be one of `Arg1` ... `ArgN`.

This notation can be simplified in several ways. If the name of the foreign function is the same as the name of the Ciao Prolog predicate, `foreign(foreign_function_name)` can be replaced by `foreign/0`. `returns(ArgR)` specifies that the result of the function corresponds to the `ArgR` argument of the Ciao Prolog predicate. If the foreign function does not return anything (or if its value is ignored), then `returns(ArgR)` must be removed. Note that `returns` cannot be used without `foreign`. A simplified, minimal form is thus:

```
:- true pred prolog_predicate(m1(Arg1), ... mN(ArgN)) ::
              type1 * ... * typeN + foreign.
```

104.2 Equivalence between Ciao Prolog and C types

The automatic translation between Ciao Prolog and C types is defined (at the moment) only for some simple but useful types. The translation to be performed is solely defined by the types of the arguments in the Ciao Prolog file (i.e., no inspection of the corresponding C file is done). The names (and meaning) of the types known for performing that translation are to be found in Chapter 105 [Foreign Language Interface Properties], page 427; they are also summarized below (Prolog types are on the left, and the corresponding C types on the right):

- num <-> double
- int <-> int
- atm <-> char *
- string <-> char * (with trailing zero)
- byte_list <-> char * (a buffer of bytes, with associated length)
- int_list <-> int * (a buffer of integers, with associated length)
- address <-> void *

Strings, atoms, and lists of bytes are passed to (and from) C as dynamically (`malloc`) created arrays of characters (bytes). Those arrays are freed by Ciao Prolog upon return of the foreign function unless the property `do_not_free/2` is specified (see examples below). This caters for the case in which the C files save in a private state (either by themselves, or by a library function being called by them) the values passed on from Prolog. The type `byte_list/1` requires an additional property, `size_of/2`, to indicate which argument represents its size.

Empty lists of bytes and integers are converted into C `NULL` pointers, and vice versa. Empty strings (`[]`) and null atoms (') are converted into zero-length, zero-ended C strings (`""`). C `NULL` strings and empty buffers (i.e., buffers with zero length) are transformed into the empty list or the null atom (`''`).

Most of the work is performed by the predicates in the Chapter 107 [Foreign Language Interface Builder], page 435, which can be called explicitly by the user. Doing that is not usually needed, since the Ciao Prolog Compiler takes care of building glue code files an of compiling and linking whatever is necessary.

104.3 Equivalence between Ciao Prolog and C modes

The (prefix) `+/1` ISO mode (or, equivalently, the in/1 mode) states that the corresponding Prolog argument is ground at the time of the call, and therefore it is an input argument in the C part; this groundness is automatically checked upon entry. The (prefix) `-/1` ISO mode (or, equivalently, the go/1 mode) states that Prolog expects the C side to generate a (ground) value for that argument. Arguments with output mode should appear in C functions as pointers to the corresponding base type (as it is usual with C), i.e., an argument which is an integer generated by the C file, declared as

```
:- true pred get_int(go(ThisInt)) :: int + foreign
```

or as

```
:- true pred get_int(-ThisInt) :: int + foreign
```

should appear in the C code as

```
void get_int(int *thisint)
{
        ....
}
```

Note the type of the (single) argument of the function. Besides, the return value of a function can always be used as an output argument, just by specifying to which Prolog arguments it corresponds, using the `foreing/1` property. The examples below illustrate this point, and the use of several assertions to guide the compilation.

104.4 Custom access to Prolog from C

Automatic type conversions does not cover all the possible cases. When the automatic type conversion is not enough (or if the user, for any reason, does not want to go through the automatic conversion), it is possible to instruct Ciao Prolog not to make implicit type conversion. The

strategy in that case is to pass the relevant argument(s) with a special type (a `ciao_term`) which can represent any term which can be built in Prolog. Operations to construct, traverse, and test this data abstraction from C are provided. The prototypes of these operations are placed on the `"ciao_prolog.h"` file, under the `include` subdirectory of the installation directory (the Ciao Prolog compiler knowns where it has been installed, and gives the C compiler the appropriate flags). This *non direct correspondence* mode is activated whenever a Ciao Prolog type unknown to the foreign interface (i.e., none of these in Chapter 105 [Foreign Language Interface Properties], page 427) or the type `any_term` (which is explicitly recognised by the foreign language interface) is found. The latter is preferred, as it is much more informative, and external tools, as the the CiaoPP preprocessor, can take advantage of them.

104.4.1 Term construction

All term construction primitives return an argument of type `ciao_term`, which is the result of constructing a term. All Ciao Prolog terms can be built using the interface operations `ciao_var()`, `ciao_structure()`, `ciao_integer()`, and `ciao_float()`. There are, however, variants and specialized versions of these operations which can be freely intermixed. Using one version or another is a matter of taste and convenience. We list below the prototypes of the primitives in order of complexity.

- `ciao_term ciao_var();`
  Returns a fresh, unbound variable.
- `ciao_term ciao_integer(int i);`
  Creates a term, representing an integer from the Prolog point of view, from a C integer.
- `ciao_term ciao_float(double i);`
  Creates a term, representing a floating point number, from a floating point number.
- `ciao_term ciao_atom(char *name);`
  Creates an atom whose printable name is given as a C string.
- `ciao_term ciao_structure_a(char *name, int arity, ciao_term *args);`
  Creates a structure with name 'name' (i.e., the functor name), arity 'arity' and the components of the array 'args' as arguments: `args[0]` will be the first argument, `args[1]` the second, and so on. The 'args' array itself is not needed after the term is created, and can thus be a variable local to a procedure. An atom can be represented as a 0-arity structure (with `ciao_structure(name, 0)`), and a list cell can be constructed using the '.'/2 structure name. The `_a` suffix stands for *array*.
- `ciao_term ciao_structure(char *name, int arity, ...);`
  Similar to ciao_structure_a, but the C arguments after the arity are used to fill in the arguments of the structure.
- `ciao_term ciao_list(ciao_term head, ciao_term tail);`
  Creates a list from a `head` and a `tail`. It is equivalent to `ciao_structure(".", 2, head, tail)`.
- `ciao_term ciao_empty_list();`
  Creates an empty list. It is equivalent to `ciao_atom("[]")`.
- `ciao_term ciao_listn_a(int len, ciao_term *args);`
  Creates a list with 'len' elements from the array `args`. The *nth* element of the list (starting at 1) is `args[n-1]` (starting at zero).
- `ciao_term ciao_listn(int length, ...);`
  Like `ciao_listn_a()`, but the list elements appear explicitly as arguments in the call.
- `ciao_term ciao_dlist_a(int len, ciao_term *args, ciao_term base);`
  Like `ciao_listn_a`, but a difference list is created. `base` whill be used as the tail of the list, instead of the empty list.

- `ciao_term ciao_dlist(int length, ...);`

  Similar to `ciao_dlist_a()` with a variable number of arguments. The last one is the tail of the list.
- `ciao_term ciao_copy_term(ciao_term src_term);`

  Returns a new copy of the `term`, with fresh variables (as `copy_term/2` does).

104.4.2 Testing the Type of a Term

A `ciao_term` can contain *any* Prolog term, and its implementation is opaque to the C code. Therefore the only way to know reliably what data is passed on is using explicit functions to test term types. Below, `ciao_bool` is a type defined in `"ciao_prolog.h"` which can take the values 1 (for **true**) and 0 (for **false**).

- `ciao_bool ciao_is_variable(ciao_term term);`

  Returns true if `term` is currently an uninstantiated variable.
- `ciao_bool ciao_is_integer(ciao_term term);`

  Returns true if `term` is instantiated to an integer.
- `ciao_bool ciao_is_number(ciao_term term);`

  Returns true if `term` is an integer or a floating point number.
- `ciao_bool ciao_is_atom(ciao_term atom);`

  Returns true if `term` is an atom.
- `ciao_bool ciao_is_list(ciao_term term);`

  Returns true if `term` is a list (actually, a `cons` cell).
- `ciao_bool ciao_is_empty_list(ciao_term term);`

  Returns true if `term` is the atom which represents the empty list (i.e., `[]`).
- `ciao_bool ciao_is_structure(ciao_term term);`

  Returns true if `term` is a structure of any arity. This includes atoms (i.e., structures of arity zero) and lists, but excludes variables and numbers.

104.4.3 Term navigation

The functions below can be used to recover the value of a `ciao_term` into C variables, or to inspect Prolog structures.

- `int ciao_to_integer(ciao_term term);`

  Converts `term` to an integer. `ciao_is_integer(term)` must hold.
- `double ciao_to_float(ciao_term term);`

  Converts `term` to a float value. `ciao_is_number(term)` must hold.
- `char *ciao_atom_name(ciao_term atom);`

  Returns the name of the atom. The returned string *is the one internally used by Ciao Prolog*, and should not be changed or altered in any form. The advantage of using it is that it is fast.
- `char *ciao_atom_name_dup(ciao_term atom);`

  Obtains a **copy** of the name of the atom. The string can be modified, and the programmer has the responsibility of deallocating it after being used. Due to the copy, it is slower than calling `char *ciao_atom_name()`.
- `ciao_term ciao_list_head(ciao_term term);`

  Extracts the head of the list `term`. Requires `term` to be a list.

- `ciao_term ciao_list_tail(ciao_term term);`

  Extracts the tail of the list `term`. Requires `term` to be a list.
- `char *ciao_structure_name(ciao_term term);`

  Extracts the name of the structure `term`. Requires `term` to be a structure.
- `int ciao_structure_arity(ciao_term term);`

  Extracts the arity of the structure `term`.

  Requires `term` to be a structure.
- `ciao_term ciao_structure_arg(ciao_term term, int n);`

  Extracts the *nth* argument of the structure `term`. It behaves like `arg/3`, so the first argument has index 1. Requires `term` to be a structure.

104.4.4 Testing for Equality and Performing Unification

Variables of type `ciao_term` cannot be tested directly for equality: they are (currently) implemented as a sort of pointers which may be aliased (two different pointers may refer to the same object). The interface provides helper functions for testing term equality and to perform unification of terms.

- `ciao_bool ciao_unify(ciao_term x, ciao_term y);`

  Performs the unification of the terms `x` and `y`, and returns true if the unification was successful. This is equivalent to calling the (infix) Prolog predicate `=/2`. The bindings are trailed and undone on backtracking.
- `ciao_bool ciao_equal(ciao_term x, ciao_term y);`

  Performs equality testing of terms, and returns true if the test was successful. This is equivalent to calling the (infix) Prolog predicate `==/2`. Equality testing does not modify the terms compared.

104.4.5 Raising Exceptions

The following functions offers a way of throwing exceptions from C that can be caught in Prolog with `catch/3`. The term that reaches Prolog is exactly the same which was thrown by C. The execution flow is broken at the point where `ciao_raise_exception()` is executed, and it returns to Prolog.

- `void ciao_raise_exception(ciao_term ball);`

  Raises an exception an throws the term `ball`.

104.4.6 Calling Prolog from C

It is also possible to make arbitraty calls to Prolog predicates from C. There are two basic ways of make a query, depending if only one solution is needed (or if the predicate to be called is known to generate only one solution), or if several solutions are required.

When only one solution is needed `ciao_commit_call` obtains it (obviously, the first) and discards the resources used for finding it:

- `ciao_bool ciao_commit_call(char *name, int arity, ...);`

  Makes a call to a predicate and returns true or false depending on whether the query has succedeed or not. In case of success, the (possibly) instantiated variables are reachable from C.
- `ciao_bool ciao_commit_call_term(ciao_term goal);`

  Like `ciao_commit_call()` but uses the previously built term `goal` as goal.

If more than one solution is needed, it is necessary to use the `ciao_query` operations. A consult begins with a `ciao_query_begin` which returns a `ciao_query` object. Whenever an additional solution is required, the `ciao_query_next` function can be called. The query ends by calling `ciao_query_end` and all pending search branches are pruned.

- `ciao_query *ciao_query_begin(char *name, int arity, ...);`
  The predicate with the given name, arity and arguments (similar to the `ciao_structure()` operation) is transformed into a `ciao_query` object which can be used to make the actual query.
- `ciao_query *ciao_query_begin_term(ciao_term goal);`
  Like ciao_query_begin but using the term `goal` instead.
- `ciao_bool ciao_query_ok(ciao_query *query);`
  Determines whether the query may have pending solutions. A false return value means that there are no more solutions; a true return value means that there are more possible solutions.
- `void ciao_query_next(ciao_query *query);`
  Ask for a new solution.
- `void ciao_query_end(ciao_query *query);`
  Ends the query and frees the used resources.

104.5 Examples

104.5.1 Mathematical functions

In this example, the standard mathematical library is accessed to provide the *sin*, *cos*, and *fabs* functions. Note that the library is specified simply as

```
:- use_foreign_library([m]).
```

The foreign interface adds the `-lm` at compile time. Note also how some additional options are added to optimize the compiled code (only glue code, in this case) and mathematics (only in the case of Linux in an Intel processor).

The functions imported from the C file, and exported as predicates by the Prolog module are stated as defined elsewhere by the directive

```
:- impl_defined([sin/2,cos/2,fabs/2]).
```

so that the Prolog compiler does not complain when examining the Prolog file.

File *math.pl*:

```
:- module(math, [sin/2, cos/2, fabs/2],
                [assertions, basicmodes, regtypes, foreign_interface]).

:- true pred sin(in(X),go(Y)) :: num * num + (foreign,returns(Y)).
:- true pred cos(in(X),go(Y)) :: num * num + (foreign,returns(Y)).
:- true pred fabs(in(X),go(Y)) :: num * num + (foreign,returns(Y)).

:- extra_compiler_opts(['-O2']).
:- extra_compiler_opts('LINUXi86',['-ffast-math']).
:- use_foreign_library([m]).

:- impl_defined([sin/2,cos/2,fabs/2]).
```

104.5.2 Addresses and C pointers

The `address` type designates any pointer, and provides a means to deal with C pointers in Prolog without interpreting them whatsoever. The C source file which implements the operations accessed from Prolog is declared with the

```
:- use_foreign_source(objects_c).
```

directive.

File *objects.pl*:

```
:- module(objects, [object/2, show_object/1],
                   [assertions, basicmodes, regtypes, foreign_interface]).

:- true pred object(in(N),go(Object)) :: int * address +
                                         (foreign,returns(Object)).

:- true pred show_object(in(Object)) :: address + foreign.

:- use_foreign_source(objects_c).
:- extra_compiler_opts('-O2').

:- impl_defined([object/2,show_object/1]).
```

File *objects_c.c*:

```
#include <stdio.h>

struct object {
  char *name;
  char *colour;
};

#define OBJECTS 3

struct object objects[OBJECTS] =
{ {"ring","golden"},
  {"table","brown"},
  {"bottle","green"} };

struct object *object(int n) {
  return &objects[n % OBJECTS];
}

void show_object(struct object *o) {
  printf("I show you a %s %s\n", o->colour, o->name);
}
```

104.5.3 Lists of bytes and buffers

A list of bytes (c.f., a list of ints) corresponds to a byte buffer in C. The length of the buffer is associated to that of the list using the property `size_of/2`. The returned buffer **is freed by Ciao Prolog** upon its recepction, unless the `do_not_free/1` property is specified (see later). Conversely, a list of natural numbers in the range 0 to 255 can be passed to C as a buffer.

File *byte_lists.pl*:

```
:- module(byte_lists, [obtain_list/3, show_list/2],
                      [assertions, basicmodes, regtypes, foreign_interface]).

:- true pred obtain_list(in(N),go(Length),go(List)) ::
             int * int * byte_list +
             (foreign,size_of(List,Length)).
:- true pred show_list(in(Length),in(List)) ::
             int * byte_list +
             (foreign,size_of(List,Length)).

:- use_foreign_source(bytes_op).

:- impl_defined([obtain_list/3,show_list/2]).
```

File *bytes_op.c*:

```
#include <malloc.h>
#include <stdio.h>

void obtain_list(int n, int *l, char **s) {
  int i, c;
  if (n < 0) n = 0;
  *l = n;
  *s = (char *)malloc(*l);
  for (i = 0; i < *l; i++) {
    (*s)[i] = i;
  }
}

void show_list(int l, char *s) {
  if (s) {
    int n;
    printf("From C: [");
    for (n = 0; n < l; n++) {
      printf(" %d", s[n]);
    }
    printf("]\n");
  } else {
    printf("From C: []\n");
  }
}
```

104.5.4 Lists of integers

File *int_lists.pl*:

```
:- module(int_lists, [obtain_list/3, show_list/2],
                     [assertions, basicmodes, regtypes, foreign_interface]).

:- true pred obtain_list(in(N),go(Length),go(List)) ::
             int * int * int_list +
             (foreign,size_of(List,Length)).
:- true pred show_list(in(Length),in(List)) ::
             int * int_list +
```

```
                (foreign,size_of(List,Length)).

:- use_foreign_source(ints_op).

:- impl_defined([obtain_list/3,show_list/2]).
```

File *ints_op.c*:

```
#include <malloc.h>
#include <stdio.h>

void obtain_list(int n, int *l, int **s) {
  int i;
  int c;
  if (n < 0) n = 0;
  *l = n;
  *s = (int *)malloc((*l) * sizeof(int));
  for (i = 0; i < *l; i++) {
    (*s)[i] = i;
  }
}

void show_list(int l, int *s) {
  if (s) {
    int n;
    printf("From C:");
    for (n = 0; n < l; n++) {
      printf(" %d", s[n]);
    }
    printf(".\n");
  } else {
    printf("From C: []\n");
  }
}
```

104.5.5 Strings and atoms

A C string can be seen as a buffer whose end is denoted by the trailing zero, and therefore stating its length is not needed. Two translations are possible into Ciao Prolog: as a Prolog string (list of bytes, with no trailing zero) and as an atom. These are selected automatically just by choosing the corresponding type (look at the examples below).

Note how the `do_not_free/1` property is specified in the `a_string/1` predicate: the string returned by C is static, and therefore it should not be freed by Prolog.

File *strings_and_atoms.pl*:

```
:- module(strings_and_atoms,
          [lookup_string/2, lookup_atom/2, a_string/1,
           show_string/1, show_atom/1],
          [assertions, basicmodes, regtypes, foreign_interface]).


:- true pred a_string(go(S)) ::  string +
             (foreign(get_static_str),returns(S),do_not_free(S)).
```

```
:- true pred lookup_string(in(N),go(S)) ::
            int * string +
            (foreign(get_str),returns(S)).
:- true pred lookup_atom(in(N),go(S)) ::
     int * atm +
            (foreign(get_str),returns(S)).

:- true pred show_string(in(S)) :: string + foreign(put_str).
:- true pred show_atom(in(S)) :: atm + foreign(put_str).

:- use_foreign_source(str_op).

:- impl_defined([lookup_string/2,lookup_atom/2,
                 show_string/1,show_atom/1, a_string/1]).
```

File *str_op.c*:

```
#include <malloc.h>
#include <stdio.h>

char *get_static_str() {
  return "this is a string Ciao Prolog should not free";
}

char *get_str(int n) {
  char *s;
  int size;
  int i;
  int c;
  if (n < 0) n = -n;
  size = (n%4) + 5;
  s = (char *)malloc(size+1);
  for (i = 0, c = ((i + n) % ('z' - 'a' + 1)) + 'a'; i < size; i++,c++) {
    if (c > 'z') c = 'a';
    s[i] = c;
  }
  s[i] = 0;
  return s;
}

void put_str(char *s) {
  if (s) {
    printf("From C: \"%s\"\n", s);
  } else {
    printf("From C: null\n");
  }
}
```

104.5.6 Arbitrary Terms

This example shows how data Prolog can be passed untouched to C code, and how it can be manipulated there.

File *any_term.pl*:

```
:- module(any_term, [custom_display_term/1, custom_create_term/2],
                    [assertions, basicmodes, regtypes, foreign_interface]).

:- true pred custom_display_term(in(X)) :: any_term + foreign.
:- true pred custom_create_term(in(L), go(X)) ::
             int * any_term + (foreign,returns(X)).

:- use_foreign_source(any_term_c).
:- extra_compiler_opts('-O2').

:- impl_defined([custom_display_term/1,custom_create_term/2]).
```

File *any_term.c*:

```
#include <stdio.h>
#include "ciao_prolog.h"

ciao_term custom_create_term(int n) {
  ciao_term t;
  t = ciao_empty_list();
  while (n > 0) {
    t = ciao_list(ciao_integer(n), t);
    n--;
  }
  return t;
}

void custom_display_term(ciao_term term) {
  if (ciao_is_atom(term)) {
    printf("<atom name=\"%s\"/>", ciao_atom_name(term));
  } else if (ciao_is_structure(term)) {
    int i;
    int a;
    a = ciao_structure_arity(term);
    printf("<structure name=\"%s\" arity=\"%d\">",
           ciao_structure_name(term), a);
    for (i = 1; i <= a; i++) {
      printf("<argument number=\"%d\">", i);
      custom_display_term(ciao_structure_arg(term, i));
      printf("</argument>");
    }
    printf("</structure>");
  } else if (ciao_is_list(term)) {
    printf("<list>");
    printf("<head>");
    custom_display_term(ciao_list_head(term));
    printf("</head>");
    printf("<tail>");
    custom_display_term(ciao_list_tail(term));
    printf("</tail>");
    printf("</list>");
  } else if (ciao_is_empty_list(term)) {
    printf("<empty_list/>");
```

```
  } else if (ciao_is_integer(term)) {
    printf("<integer value=\"%d\"/>", ciao_to_integer(term));
  } else if (ciao_is_number(term)) {
    printf("<float value=\"%f\"/>", ciao_to_float(term));
  } else {
    printf("<unknown/>");
  }
}
```

104.5.7 Exceptions

The following example defines a predicate in C that converts a list of codes into a number using `strtol()`. If this conversion fails, then a exception is raised.

File *exceptions_example.pl*:

```
:- module(exceptions_example,
          [codes_to_number_c/2, safe_codes_to_number/2],
          [assertions, basicmodes, regtypes, foreign_interface]).

:- use_module(library(format)).

% If the string is not a number, an exception is raised.
:- true pred codes_to_number_c(in(X), go(Y)) ::
             string * int + (foreign, returns(Y)).

safe_codes_to_number(X, Y) :-
        catch(codes_to_number_c(X, Y), Error, handle_exception(Error)).

handle_exception(Error) :- format("Exception caught ~w~n", [Error]).

:- use_foreign_source(exceptions_c).
:- extra_compiler_opts('-O2').

:- impl_defined([codes_to_number_c/2]).
```

File *exceptions_c.c*:

```
#include <string.h>
#include "ciao_prolog.h"

int codes_to_number_c(char *s) {
  char *endptr;
  int n;
  n = strtol(s, &endptr, 10);
  if (endptr == NULL || *endptr != '\0') {
    ciao_raise_exception(ciao_structure("codes_to_number_exception", 1,
                         ciao_atom(s)));
  }
  return n;
}
```

104.6 Usage and interface (`foreign_interface`)

- **Library usage:**
  The foreign interface is used by including `foreign_interface` in the include list of a module, or by means of an explicit `:- use_package(foreign_interface)`.

105 Foreign Language Interface Properties

Author(s): Jose Morales, Manuel Carro.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#77 (2001/3/26, 18:45:31 CEST)

105.1 Usage and interface (foreign_interface_properties)

- **Library usage:**
  `:- use_module(library(foreign_interface_properties)).`
- **Exports:**
  - *Properties:*
    `native/1`, `native/2`, `size_of/3`, `foreign/1`, `foreign/2`, `returns/2`, `do_not_free/2`.
  - *Regular Types:*
    `int_list/1`, `byte_list/1`, `byte/1`, `null/1`, `address/1`, `any_term/1`.

105.2 Documentation on exports (foreign_interface_properties)

int_list/1: REGTYPE
Usage: `int_list(List)`
- *Description:* `List` is a list of integers.

byte_list/1: REGTYPE
Usage: `byte_list(List)`
- *Description:* `List` is a list of bytes.

byte/1: REGTYPE
Usage: `byte(Byte)`
- *Description:* `Byte` is a byte.

null/1: REGTYPE
Usage: `null(Address)`
- *Description:* `Address` is a null adress.

address/1: REGTYPE
Usage: `address(Address)`
- *Description:* `Address` is a memory address.

any_term/1: REGTYPE

Usage: `any_term(X)`

- *Description:* `X` is any term. The foreign interface passes it to C functions as a general term.

native/1: PROPERTY

Usage: `native(Name)`

- *Description:* The Prolog predicate `Name` is implemented using the function `Name`. The implementation is not a common C one, but it accesses directly the internal Ciao Prolog data structures and functions, and therefore no glue code is generated for it.

native/2: PROPERTY

Usage: `native(PrologName,ForeignName)`

- *Description:* The Prolog predicate `PrologName` is implemented using the function prolog_`ForeignName`. The same considerations as above example are to be applied.

size_of/3: PROPERTY

Usage: `size_of(Name,ListVar,SizeVar)`

- *Description:* For predicate `Name`, the size of the argument of type `byte_list/1`, `ListVar`, is given by the argument of type integer `SizeVar`.

foreign/1: PROPERTY

Usage: `foreign(Name)`

- *Description:* The Prolog predicate `Name` is implemented using the foreign function `Name`.

foreign/2: PROPERTY

Usage: `foreign(PrologName,ForeignName)`

- *Description:* The Prolog predicate `PrologName` is implemented using the foreign function `ForeignName`.

returns/2: PROPERTY

Usage: `returns(Name,Var)`

- *Description:* The result of the foreign function that implements the Prolog predicate `Name` is unified with the Prolog variable `Var`. Cannot be used without `foreign/1` or `foreign/2`.

do_not_free/2: PROPERTY

Usage: `do_not_free(Name,Var)`

- *Description:* For predicate `Name`, the C argument passed to (returned from) the foreign function will not be freed after calling the foreign function.

105.3 Documentation on internals (foreign_interface_properties)

use_foreign_source/1: DECLARATION

Usage: :- `use_foreign_source(Files)`.

- *Description:* `Files` is the (list of) foreign file(s) that will be linked with the glue-code file.
- *The following properties hold at call time:*

  `Files` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

use_foreign_source/2: DECLARATION

Usage: :- `use_foreign_source(OsArch,Files)`.

- *Description:* `Files` are the OS and architecture dependant foreign files. This allows compiling and linking different files depending on the O.S. and architecture.
- *The following properties hold at call time:*

  `OsArch` is an atom. (`basic_props:atm/1`)

  `Files` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

use_foreign_library/1: DECLARATION

Usage: :- `use_foreign_library(Libs)`.

- *Description:* `Libs` is the (list of) external library(es) needed to link the C files. Only the short name of the library (i.e., what would follow the `-l` in the linker is needed.
- *The following properties hold at call time:*

  `Libs` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

use_foreign_library/2: DECLARATION

Usage: :- `use_foreign_library(OsArch,Libs)`.

- *Description:* `Libs` are the OS and architecture dependant libraries.
- *The following properties hold at call time:*

  `OsArch` is an atom. (`basic_props:atm/1`)

  `Libs` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

extra_compiler_opts/1: DECLARATION

Usage: :- `extra_compiler_opts(Opts)`.

- *Description:* `Opts` is the list of additional compiler options (e.g., optimization options) that will be used during the compilation.
- *The following properties hold at call time:*

  `Opts` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

extra_compiler_opts/2: DECLARATION

Usage: `:- extra_compiler_opts(OsArch,Opts).`

- *Description:* `Opts` are the OS and architecture dependant additional compiler options.
- *The following properties hold at call time:*

  `OsArch` is an atom. (`basic_props:atm/1`)

  `Opts` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

use_compiler/1: DECLARATION

Usage: `:- use_compiler(Compiler).`

- *Description:* `Compiler` is the compiler to use in this file. When this option is used, the default (Ciao-provided) compiler options are not used; those specified in `extra_compiler_options` are used instead.
- *The following properties hold at call time:*

  `Compiler` is an atom. (`basic_props:atm/1`)

use_compiler/2: DECLARATION

Usage: `:- use_compiler(OsArch,Compiler).`

- *Description:* `Compiler` is the compiler to use in this file when compiling for the architecture `OsArch`. The option management is the same as in `use_compiler/2`.
- *The following properties hold at call time:*

  `OsArch` is an atom. (`basic_props:atm/1`)

  `Compiler` is an atom. (`basic_props:atm/1`)

extra_linker_opts/1: DECLARATION

Usage: `:- extra_linker_opts(Opts).`

- *Description:* `Opts` is the list of additional linker options that will be used during the linkage.
- *The following properties hold at call time:*

  `Opts` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

extra_linker_opts/2: DECLARATION

Usage: `:- extra_linker_opts(OsArch,Opts).`

- *Description:* `Opts` are the OS and architecture dependant additional linker options.
- *The following properties hold at call time:*

  `OsArch` is an atom. (`basic_props:atm/1`)

  `Opts` is an atom or a list of atoms. (`basic_props:atm_or_atm_list/1`)

use_linker/1: DECLARATION

Usage: `:- use_linker(Linker).`

- *Description:* `Linker` is the linker to use in this file. When this option is used, the default (Ciao-provided) linker options are not used; those specified in `extra_linker_options/1` are used instead.

– *The following properties hold at call time:*
`Linker` is an atom. (`basic_props:atm/1`)

use_linker/2: DECLARATION

Usage: `:- use_linker(OsArch,Linker).`

– *Description:* `Compiler` is the linker to use in this file when compiling for the architecture `OsArch`. The option management is the same as in `use_compiler/2`.

– *The following properties hold at call time:*
`OsArch` is an atom. (`basic_props:atm/1`)
`Linker` is an atom. (`basic_props:atm/1`)

105.4 Known bugs and planned improvements (`foreign_interface_properties`)

- The `size_of/3` property has an empty definition

106 Utilities for on-demand compilation of foreign files

Author(s): Manuel Carro, Jose Morales.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.3#36 (1999/7/20, 10:37:31 MEST)

This module provides two predicates which give the user information regarding how to compile external (C) files in order to link them with the Ciao Prolog engine at runtime.

These predicates are not intended to be called directly by the end-user. Instead, a tool or module whose aim is generating dynamically loadable files from source files should use the predicates in this file in order to find out what are the proper compiler and linker to use, and which options must be passed to them in the current architecture.

106.1 Usage and interface (foreign_compilation)

- **Library usage:**

  `:- use_module(library(foreign_compilation)).`
- **Exports:**
  - *Predicates:*

    `compiler_and_opts/2`, `linker_and_opts/2`.
- **Other modules used:**
  - *System library modules:*

    `system`.

106.2 Documentation on exports (foreign_compilation)

compiler_and_opts/2: PREDICATE

Usage: `compiler_and_opts(?Compiler,?Opts)`

- *Description:* If you want to compile a foreign language file for dynamic linking in the current operating system and architecture, you have to use the compiler `Compiler` and give it the options `Opts`. A variable in `Opts` means that no special option is needed.
- *The following properties should hold at call time:*

  `?Compiler` is currently instantiated to an atom. (`term_typing:atom/1`)

  `?Opts` is a list of `atoms`. (`basic_props:list/2`)

linker_and_opts/2: PREDICATE

Usage: `linker_and_opts(?Linker,?Options)`

- *Description:* If you want to link a foreign language file for dynamic linking in the current operating system and architecture, you have to use the linker `Compiler` and gite it the options `Opts`. A variable in `Opts` means that no special option is needed.
- *The following properties should hold at call time:*

  `?Linker` is currently instantiated to an atom. (`term_typing:atom/1`)

  `?Options` is a list of `atoms`. (`basic_props:list/2`)

107 Foreign Language Interface Builder

Author(s): Jose Morales, Manuel Carro.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#212 (2002/5/6, 1:12:2 CEST)

107.1 Usage and interface (build_foreign_interface)

- **Library usage:**
  `:- use_module(library(build_foreign_interface)).`
- **Exports:**
  - *Predicates:*
    `build_foreign_interface/1`, `rebuild_foreign_interface/1`, `build_foreign_interface_explicit_decls/2`, `rebuild_foreign_interface_explicit_decls/2`, `build_foreign_interface_object/1`, `rebuild_foreign_interface_object/1`, `do_interface/1`.
- **Other modules used:**
  - *System library modules:*
    `c/c`, `streams`, `terms`, `lists`, `llists`, `aggregates`, `system`, `format`, `messages`, `assertions/assrt_lib`, `foreign_compilation`, `compiler/c_itf`, `ctrlcclean`, `errhandle`.

107.2 Documentation on exports (build_foreign_interface)

build_foreign_interface/1: PREDICATE

Usage 1: `build_foreign_interface(in(File))`

- *Description:* Reads assertions from `File`, generates the gluecode for the Ciao Prolog interface, compiles the foreign files and the gluecode file, and links everything in a shared object. Checks modification times to determine automatically which files must be generated/compiled/linked.
- *Call and exit should be compatible with:*
  `in(File)` is a source name. (`streams_basic:sourcename/1`)

Usage 2: `build_foreign_interface(in(File))`

- *Description:* Like `build_foreign_interface/1`, but it does not check the modification time of any file.
- *Call and exit should be compatible with:*
  `in(File)` is a source name. (`streams_basic:sourcename/1`)

rebuild_foreign_interface/1: PREDICATE

No further documentation available for this predicate.

build_foreign_interface_explicit_decls/2: PREDICATE

Usage: `build_foreign_interface_explicit_decls(in(File),in(Decls))`

- *Description:* Like `build_foreign_interface/1`, but use declarations in `Decls` instead of reading the declarations from `File`.
- *Call and exit should be compatible with:*

  `in(File)` is a source name. (`streams_basic:sourcename/1`)

  `in(Decls)` is a list of `terms`. (`basic_props:list/2`)

rebuild_foreign_interface_explicit_decls/2: PREDICATE

Usage: `rebuild_foreign_interface_explicit_decls(in(File),in(Decls))`

- *Description:* Like `build_foreign_interface_explicit_decls/1`, but it does not check the modification time of any file.
- *Call and exit should be compatible with:*

  `in(File)` is a source name. (`streams_basic:sourcename/1`)

  `in(Decls)` is a list of `terms`. (`basic_props:list/2`)

build_foreign_interface_object/1: PREDICATE

Usage: `build_foreign_interface_object(in(File))`

- *Description:* Compiles the gluecode file with the foreign source files producing an unique object file.
- *Call and exit should be compatible with:*

  `in(File)` is a source name. (`streams_basic:sourcename/1`)

rebuild_foreign_interface_object/1: PREDICATE

Usage: `rebuild_foreign_interface_object(in(File))`

- *Description:* Compiles (again) the gluecode file with the foreign source files producing an unique object file.
- *Call and exit should be compatible with:*

  `in(File)` is a source name. (`streams_basic:sourcename/1`)

do_interface/1: PREDICATE

Usage: `do_interface(in(Decls))`

- *Description:* Given the declarations in `Decls`, this predicate succeeds if these declarations involve the creation of the foreign interface
- *Call and exit should be compatible with:*

  `in(Decls)` is a list of `terms`. (`basic_props:list/2`)

108 Interface to daVinci

Author(s): Francisco Bueno.

This library allows connecting a Ciao Prolog application with daVinci V2.X.

The communication is based on a two-way channel: after daVinci is started, messages are sent in to it and read in from it on demand by different Prolog predicates. Messages are sent via writing the term as text; messages are received by reading text and returning an atom. Commands sent and answers received are treated as terms from the Prolog side, since for daVinci they are text but have term syntax; the only difficulty lies in strings, for which special Prolog syntax is provided.

See accompanying file `library('davinci/commands')` for examples on the use of this library.

daVinci is developed by U. of Bremen, Germany.

108.1 Usage and interface (`davinci`)

- **Library usage:**

  ```
  :- use_module(library(davinci)).
  ```

- **Exports:**
  - *Predicates:*

    `davinci/0`, `topd/0`, `davinci_get/1`, `davinci_get_all/1`, `davinci_put/1`, `davinci_quit/0`, `davinci_ugraph/1`, `davinci_lgraph/1`, `ugraph2term/2`, `formatting/2`.
- **Other modules used:**
  - *System library modules:*

    `aggregates`, `prompt`, `errhandle`, `format`, `read`, `graphs/ugraphs`, `write`, `system`.

108.2 Documentation on exports (`davinci`)

davinci/0: PREDICATE

Start up a daVinci process.

topd/0: PREDICATE

A toplevel to send to daVinci commands from standard input.

davinci_get/1: PREDICATE

Usage: `davinci_get(Term)`

- *Description:* Get a message from daVinci. `Term` is a term corresponding to daVinci's message.

davinci_get_all/1: PREDICATE

Usage: `davinci_get_all(List)`

- *Description:* Get all pending messages. `List` is a list of terms as in `davinci_get/1`.

– *The following properties should hold upon exit:*
`List` is a list. (`basic_props:list/1`)

davinci_put/1: PREDICATE

Usage: `davinci_put(Term)`

– *Description:* Send a command to daVinci.
– *The following properties should hold at call time:*
`davinci:davinci_command(Term)` (`davinci:davinci_command/1`)

davinci_quit/0: PREDICATE

Exit daVinci process. All pending answers are lost!

davinci_ugraph/1: PREDICATE

Usage: `davinci_ugraph(Graph)`

– *Description:* Send a graph to daVinci.
– *The following properties should hold at call time:*
`davinci:ugraph(Graph)` (`davinci:ugraph/1`)

davinci_lgraph/1: PREDICATE

Usage: `davinci_lgraph(Graph)`

– *Description:* Send a labeled graph to daVinci.
– *The following properties should hold at call time:*
`davinci:lgraph(Graph)` (`davinci:lgraph/1`)

ugraph2term/2: PREDICATE

No further documentation available for this predicate.

formatting/2: PREDICATE

No further documentation available for this predicate.

108.3 Documentation on internals (`davinci`)

davinci_command/1: PROPERTY

Syntactically, a command is a term. Semantically, it has to correspond to a command understood by daVinci. Two terms are interpreted in a special way: `string/1` and `text/1`: `string(Term)` is given to daVinci as `"Term"`; `text(List)` is given as `"Term1 Term2 ...Term "` for each `Term` in `List`. If your term has functors `string/1` and `text/1` that you don't want to be interpreted this way, use it twice, i.e., `string(string(Term))` is given to daVinci as `string(Term')` where `Term'` is the interpretation of `Term`.

ugraph/1: PROPERTY

`ugraph(Graph)`

`Graph` is a term which denotes an ugraph as in `library(ugraphs)`. Vertices of the form `node/2` are interpreted in a special way: `node(Term,List)` is interpreted as a vertex `Term` with attributes `List`. `List` is a list of terms conforming the syntax of `davinci_put/1` and corresponding to daVinci's graph nodes attributes. If your vertex has functor `node/2` and you don't want it to be interpreted this way, use it twice, i.e., `node(node(T1,T2),[])` is given to daVinci as vertex `node(T1,T2)`. A vertex is used both as label and name of daVinci's graph node. daVinci's graph edges have label `V1-V2` where `V1` is the source and `V2` the sink of the edge. There is no support for multiple edges between the same two vertices.

lgraph/1: PROPERTY

`lgraph(Graph)`

`Graph` is a term which denotes a wgraph as in `library(wgraphs)`, except that the weights are labels, i.e., they do not need to be integers. Vertices of the form `node/2` are interpreted in a special way. Edge labels are converted into special intermediate vertices. Duplicated labels are solved by adding dummy atoms `''`. There is no support for multiple edges between the same two vertices.

109 The Tcl/Tk interface

Author(s): Montse Iglesias Urraca, `http://www.clip.dia.fi.upm.es/`, The CLIP Group, Facultad de Informática, Universidad Politécnica de Madrid.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#123 (2001/9/2, 14:13:25 CEST)

The `tcltk` library package is a bidirectional interface to the *Tcl* (pronounced Tickle) language and *Tk* toolkit. Tcl is an interpreter scripting language with many extension packages, in particular the graphical interface toolkit Tk. The interaction between both languages is implemented as an interface between two processes, a Tcl/Tk process and a Prolog process. The approach allows programmers to program both in Tcl/Tk and Prolog.

Prolog - Tcl/Tk interface structure

The interface is made up of two parts: a Prolog part and a Tcl/Tk part. The Prolog part encodes the requests from a Prolog program and sends them to the Tcl/Tk part via a socket. The Tcl/Tk part receives from this socket and performs the actions included implied by the requests.

Prolog side of the Prolog - Tcl/Tk interface

The Prolog side receives the actions to perform in the Tcl/Tk side from the user program and sends them to the Tcl/Tk side through the socket connection. When the action is finished in the Tcl/Tk side, the result is returned to the user program, or the action fails if any problem occurs.

Tcl/Tk side of the Prolog - Tcl/Tk interface

The Tcl/Tk side waits for requests from the Prolog side, executes the Tcl/Tk code sent from the Prolog side. At the same time, the Tcl/Tk side handles the events and exceptions raised in the Tcl/Tk side, possibly passing on control to the Prolog side.

109.1 Usage and interface (`tcltk`)

- **Library usage:**
  `:- use_module(library(tcltk)).`
- **Exports:**
  - *Predicates:*
    `tcl_new/1`, `tcl_eval/3`, `tcl_delete/1`, `tcl_event/3`, `tk_event_loop/1`, `tk_loop/1`, `tk_new/2`, `tk_next_event/2`.
  - *Regular Types:*
    `tclInterpreter/1`, `tclCommand/1`.
- **Other modules used:**
  - *System library modules:*
    `tcltk/tcltk_low_level`, `write`, `strings`, `lists`.

109.2 Documentation on exports (`tcltk`)

tclInterpreter/1: REGTYPE

To use Tcl, you must create a *Tcl interpreter* object and send commands to it.

Usage: `tclInterpreter(I)`

– *Description:* `I` is a reference to a *Tcl* interpreter.

tclCommand/1: REGTYPE

A *Tcl* command is specified as follows:

```
Command         --> Atom  { other than [] }
                  | Number
                  | chars(PrologString)
                  | write(Term)
                  | format(Fmt,Args)
                  | dq(Command)
                  | br(Command)
                  | sqb(Command)
                  | min(Command)
                  | ListOfCommands
ListOfCommands  --> []
                  |[Command|ListOfCommands]
```

where:

`Atom` denotes the printed representation of the atom.

`Number` denotes their printed representations.

`chars(PrologString)`
denotes the string represented by *PrologString* (a list of character codes).

`write(Term)`
denotes the string that is printed by the corresponding built-in predicate.

`format(Term)`
denotes the string that is printed by the corresponding built-in predicate.

`dq(Command)`
denotes the string specified by *Command*, enclosed in double quotes.

`br(Command)`
denotes the string specified by *Command*, enclosed in braces.

`sqb(Command)`
denotes the string specified by *Command*, enclosed in square brackets.

`min(Command)`
denotes the string specified by *Command*, immediately preceded by a hyphen.

`ListOfCommands`
denotes the strings denoted by each element, separated by spaces.

Usage: `tclCommand(C)`

– *Description:* `C` is a *Tcl* command.

tcl_new/1: PREDICATE

Usage: `tcl_new(-TclInterpreter)`

– *Description:* Creates a new interpreter, initializes it, and returns a handle to it in `TclInterpreter`.

– *Call and exit should be compatible with:*
`-TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

tcl_eval/3: PREDICATE

Usage: `tcl_eval(+TclInterpreter,+Command,-Result)`

- *Description:* Evaluates the commands given in `Command` in the Tcl interpreter `TclInterpreter`. The result will be stored as a string in `Result`. If there is an error in *Command* an exception is raised. The error messages will be *Tcl Exception:* if the error is in the syntax of the tcltk code or *Prolog Exception:*, if the error is in the prolog term.
- *Call and exit should be compatible with:*

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

  `+Command` is a *Tcl* command. (`tcltk:tclCommand/1`)

  `-Result` is a string (a list of character codes). (`basic_props:string/1`)

tcl_delete/1: PREDICATE

Usage: `tcl_delete(+TclInterpreter)`

- *Description:* Given a handle to a Tcl interpreter in variable `TclInterpreter`, it deletes the interpreter from the system.
- *Call and exit should be compatible with:*

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

tcl_event/3: PREDICATE

Usage: `tcl_event(+TclInterpreter,+Command,-Events)`

- *Description:* Evaluates the commands given in `Command` in the Tcl interpreter whose handle is provided in `TclInterpreter`. `Events` is a list of terms stored from Tcl by *prolog_event*. Blocks until there is something on the event queue
- *Call and exit should be compatible with:*

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

  `+Command` is a *Tcl* command. (`tcltk:tclCommand/1`)

  `-Events` is a list. (`basic_props:list/1`)

tk_event_loop/1: PREDICATE

Usage: `tk_event_loop(+TclInterpreter)`

- *Description:* Waits for an event and executes the goal associated to it. Events are stored from Tcl with the *prolog* command. The unified term is sent to the Tcl interpreter in order to obtain the value of the tcl array of *prolog_variables*. If the term received does not have the form `execute(Goal)`, the predicate silently exits. If the execution of `Goal` raises a Prolog error, the interpreter is deleted and an error message is given.
- *Call and exit should be compatible with:*

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

tk_loop/1: PREDICATE

Usage: `tk_loop(+TclInterpreter)`

- *Description:* Passes control to Tk until all windows are gone.
- *Call and exit should be compatible with:*

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

tk_new/2: PREDICATE

Usage: `tk_new(+Options,-TclInterpreter)`

- *Description:* Performs basic Tcl and Tk initialization and creates the main window of a Tk application.`Options` is a list of optional elements according to:

  `name(+ApplicationName)`
  : Sets the Tk main window title to `ApplicationName`. It is also used for communicating between Tcl/Tk applications via the Tcl *send* command. Default name is an empty string.

  `display(+Display)`
  : Gives the name of the screen on which to create the main window. Default is normally determined by the `DISPLAY` environment variable.

  `file`
  : Opens the sript `file`. Commands will not be read from standard input and the execution returns back to Prolog only after all windows (and the interpreter) have been deleted.

- *Call and exit should be compatible with:*

  `+Options` is a list. (`basic_props:list/1`)

  `-TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

tk_next_event/2: PREDICATE

Usage: `tk_next_event(+TclInterpreter,-Event)`

- *Description:* Processes events until there is at least one Prolog event associated with `TclInterpreter`. `Event` is the term correspondig to the head of a queue of events stored from Tcl with the *prolog_event* command.
- *Call and exit should be compatible with:*

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk:tclInterpreter/1`)

  `-Event` is a string (a list of character codes). (`basic_props:string/1`)

110 Low level interface library to Tcl/Tk

Author(s): Montse Iglesias Urraca.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#124 (2001/9/2, 14:14:25 CEST)

The `tcltk_low_level` library defines the low level interface used by the `tcltk` library. Essentially it includes all the code related directly to the handling of sockets and processes. This library should normally not be used directly by user programs, which use `tcltk` instead. On the other hand in some cases it may be useful to undertand how this library works in order to understand possible problems in programs that use the `tcltk` library.

110.1 Usage and interface (`tcltk_low_level`)

- **Library usage:**

  `:- use_module(library(tcltk_low_level)).`
- **Exports:**
  - *Predicates:*

    `new_interp/1`, `new_interp/2`, `new_interp_file/2`, `tcltk/2`, `tcltk_raw_code/2`, `receive_result/2`, `send_term/2`, `receive_event/2`, `receive_list/2`, `receive_confirm/2`, `delete/1`.
- **Other modules used:**
  - *System library modules:*

    `terms`, `sockets/sockets`, `system`, `write`, `read`, `strings`, `lists`, `format`.

110.2 Documentation on exports (`tcltk_low_level`)

new_interp/1: PREDICATE

Usage: `new_interp(-TclInterpreter)`

- *Description:* Creates two sockets to connect to the *wish* process, the term socket and the event socket, and opens a pipe to process *wish* in a new shell.
- *Call and exit should be compatible with:*

  `-TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

new_interp/2: PREDICATE

Usage: `new_interp(-TclInterpreter,+Options)`

- *Description:* Creates two sockets, the term socket and the event socket, and opens a pipe to process *wish* in a new shell invoked with the `Options`.
- *Call and exit should be compatible with:*

  `-TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

  `+Options` is currently instantiated to an atom. (`term_typing:atom/1`)

new_interp_file/2: PREDICATE

Usage: `new_interp_file(+FileName,-TclInterpreter)`

- *Description:* Creates two sockets, the term socket and the event socket, and opens a pipe to process *wish* in a new shell invoked with a `FileName`. `FileName` is treated as a name of a sript file
- *Call and exit should be compatible with:*

  `+FileName` is a string (a list of character codes). (`basic_props:string/1`)

  `-TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

tcltk/2: PREDICATE

Usage: `tcltk(+Code,+TclInterpreter)`

- *Description:* Sends the `Code` converted to string to the `TclInterpreter`
- *Call and exit should be compatible with:*

  `+Code` is a *Tcl* command. (`tcltk_low_level:tclCommand/1`)

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

tcltk_raw_code/2: PREDICATE

Usage: `tcltk_raw_code(+String,+TclInterpreter)`

- *Description:* Sends the tcltk code items of the `Stream` to the `TclInterpreter`
- *Call and exit should be compatible with:*

  `+String` is a string (a list of character codes). (`basic_props:string/1`)

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

receive_result/2: PREDICATE

Usage: `receive_result(-Result,+TclInterpreter)`

- *Description:* Receives the `Result` of the last *TclCommand* into the `TclInterpreter`. If the *TclCommand* is not correct the *wish* process is terminated and a message appears showing the error
- *Call and exit should be compatible with:*

  `-Result` is a string (a list of character codes). (`basic_props:string/1`)

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

send_term/2: PREDICATE

Usage: `send_term(+String,+TclInterpreter)`

- *Description:* Sends the goal executed to the `TclInterpreter`. `String` has the predicate with unified variables
- *Call and exit should be compatible with:*

  `+String` is a string (a list of character codes). (`basic_props:string/1`)

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

receive_event/2: PREDICATE

Usage: `receive_event(-Event,+TclInterpreter)`

- *Description:* Receives the `Event` from the event socket of the `TclInterpreter`.
- *Call and exit should be compatible with:*

  `-Event` is a list. (`basic_props:list/1`)

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

receive_list/2: PREDICATE

Usage: `receive_list(-List,+TclInterpreter)`

- *Description:* Receives the `List` from the event socket of the `TclInterpreter`.The `List` has all the predicates that have been inserted from Tcl/Tk with the command prolog_event. It is a list of terms.
- *Call and exit should be compatible with:*

  `-List` is a list. (`basic_props:list/1`)

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

receive_confirm/2: PREDICATE

Usage: `receive_confirm(-String,+TclInterpreter)`

- *Description:* Receives the `String` from the event socket of the `TclInterpreter` when a term inserted into the event queue is managed.
- *Call and exit should be compatible with:*

  `-String` is a string (a list of character codes). (`basic_props:string/1`)

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

delete/1: PREDICATE

Usage: `delete(+TclInterpreter)`

- *Description:* Terminates the *wish* process and closes the pipe, term socket and event socket. Deletes the interpreter `TclInterpreter` from the system
- *Call and exit should be compatible with:*

  `+TclInterpreter` is a reference to a *Tcl* interpreter. (`tcltk_low_level:tclInterpreter/1`)

110.3 Documentation on internals (`tcltk_low_level`)

core/1: PREDICATE

Usage: `core(+String)`

- *Description:* `core/1` is a set of facts which contain `String`s to be sent to the Tcl/Tk interpreter on startup. They implement miscelaneous Tcl/Tk procedures which are used by the Tcl/Tk interface.
- *Call and exit should be compatible with:*

  `+String` is a string (a list of character codes). (`basic_props:string/1`)

110.4 Other information (`tcltk_low_level`)

Two sockets are created to connect the *TclInterpreter* and the prolog process: the *event_socket* and the *term_socket*. There are two global variables: *prolog_variables* and *terms*. The value of any of the variables in the goal that is bound to a term will be stored in the array `prolog_variables` with the variable name as index. The string which contains the printed representation of prolog *terms* is *Terms*. These are the Tcl/Tk procedures which implement the interface (the code is inside the `tcltk_low_level` library):

`prolog` Sends to *term_socket* the predicate tcl_result which contains the goal to execute. Returns the string executes and the goal.

`prolog_event`
Adds the new *term* to the *terms* queue.

`prolog_delete_event`
Deletes the first *term* of the *terms* queue.

`prolog_list_events`
Sends all the *terms* of the *terms* queue by the *event_socket*. The last element will be *end_of_event_list*.

`prolog_cmd`
Receives as an argument the tcltk code. Evaluates the code and returns through the *term_socket* the term *tcl_error* if there was a mistake in the code or the predicate *tcl_result* with the result of the command executed. If the argument is *prolog* with a goal to execute, before finishing, the predicate evaluated by prolog is received. In order to get the value of the variables, predicates are compared using the *unify_term* procedure. Returs 0 when the sript runs without errors, and 1 if there is an error.

`prolog_one_event`
Receives as an argument the *term* which is associated with one of the tk events. Sends through the *event_socket* the *term* and waits the unificated *term* by prolog. After that it calls the *unify_term* procedure to obtain the value of the *prolog_variables*.

`prolog_thread_event`
Receives as an argument the *term* which is associated with one of the tk events. Sends through the *event_socket* the *term* and waits for the *term* unified by prolog. After that the *unify_term* procedure is called to obtain the value of the *prolog_variables*. In this case the *term_socket* is non blocking.

`convert_variables`
Receives as an argument a string which contains symbols that can't be sent by the sockets. This procedure deletes them from the input string and returns the new string.

`unify_term`
Receives as argument a prolog term.

111 The Tcl/Tk Class Interface

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This library implements an object-orented graphical library with a number of predefined objects, using the Prolog Tcl/Tk interface. This interface allows creating and destroying objects and modifying their properties. The `window_class` contains three clases: widget class, menu class, and canvas class. The constructor class is window_class.

Note: This library (and the documentation) are still under development.

111.1 Usage and interface (`window_class`)

- **Library usage:**

  `:- use_module(library(window_class)).`
- **Exports:**
  - *Predicates:*

    `window_class/0`, `window_class/3`, `destructor/0`, `show/0`, `hide_/0`, `title/1`, `maxsize/2`, `minsize/2`, `withdraw/0`, `event_loop/0`.
  - *Regular Types:*

    `widget/1`, `option/1`, `menu/1`, `canvas/1`.
- **Other modules used:**
  - *System library modules:*

    `objects/objects_rt`, `system`, `strings`, `lists`, `tcltk/tcltk`, `tcltk/tcltk_low_level`, `aggregates`.

111.2 Documentation on exports (`window_class`)

widget/1: REGTYPE

Each `Widget` type is characterized in two ways: first, the form of the create command used to create instances of the type; and second, a set of configuration options for items of that type, which may be used in the create and itemconfigure widget commands.

Usage: `widget(W)`

- *Description:* `W` is a reference to one type of the widget widgets.

option/1: REGTYPE

Usage: `option(O)`

- *Description:* `O` is *hidden* if the Widget is not visible or *shown* if its visible.

menu/1: REGTYPE

Usage: `menu(M)`

- *Description:* `M` is a reference to one type of the menu.

canvas/1: REGTYPE

Usage: `canvas(C)`

– *Description:* `C` is a reference to one type of the canvas.

window_class/0: PREDICATE

Usage:

– *Description:* Creates a new interpreter, asserting the predicate *interp(I)*, and the widgets, menus and canvases objects.

window_class/3: PREDICATE

Usage: `window_class(+WidgetList,+MenusList,+CanvasList)`

– *Description:* Adds the widgets, menus and canvases in the list to the window object.

– *Call and exit should be compatible with:*

`+WidgetList` is a list. (`basic_props:list/1`)

`+MenusList` is a list. (`basic_props:list/1`)

`+CanvasList` is a list. (`basic_props:list/1`)

destructor/0: PREDICATE

Usage:

– *Description:* Deletes the widgets, menus and canvases of the window object and the window object.

show/0: PREDICATE

Usage:

– *Description:* Adds widgets, menus and canvas to the window object.

hide_/0: PREDICATE

Usage:

– *Description:* Removes widgets, menus and canvas from the window object.

title/1: PREDICATE

Usage: `title(+X)`

– *Description:* `X` specifies the title for window. The default window title is the name of the window.

– *Call and exit should be compatible with:*

`+X` is a string (a list of character codes). (`basic_props:string/1`)

maxsize/2: PREDICATE

Usage: `maxsize(+X,+Y)`

- *Description:* `X` specifies the maximum width and `Y` the maximum height for the window.
- *Call and exit should be compatible with:*

  `+X` is an integer. (`basic_props:int/1`)

  `+Y` is an integer. (`basic_props:int/1`)

minsize/2: PREDICATE

Usage: `minsize(+X,+Y)`

- *Description:* `X` specifies the minimum width and `Y` the minimum height for the window.
- *Call and exit should be compatible with:*

  `+X` is an integer. (`basic_props:int/1`)

  `+Y` is an integer. (`basic_props:int/1`)

withdraw/0: PREDICATE

Usage:

- *Description:* Arranges for window to be withdrawn from the screen.

event_loop/0: PREDICATE

Usage:

- *Description:* Waits for a *Tcl/Tk* event.

112 widget_class (library)

112.1 Usage and interface (widget_class)

- **Library usage:**
  `:- use_module(library(widget_class)).`
- **Exports:**
  - *Predicates:*
    `text_characters/1`, `font_type/1`, `background_color/1`, `borderwidth_value/1`, `foreground_color/1`, `highlightbackground_color/1`, `highlight_color/1`, `width_value/1`,
    `relief_type/1`, `side_type/1`, `expand_value/1`, `fill_type/1`, `padx_value/1`, `pady_value/1`, `row_value/1`, `rowspan_value/1`, `column_value/1`, `columnspan_value/1`, `event_type_widget/1`, `action_widget/3`, `action_widget/1`, `creation_options/1`, `creation_position/1`, `creation_position_grid/1`, `creation_bind/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

112.2 Documentation on exports (widget_class)

text_characters/1: PREDICATE

Usage 1: `text_characters(+Text)`

- *Description:* Indicates the `Text` to be displayed in the widget.
- *Call and exit should be compatible with:*
  `+Text` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `text_characters(-Text)`

- *Description:* `Text` which is displayed in the widget.
- *Call and exit should be compatible with:*
  `-Text` is currently instantiated to an atom. (`term_typing:atom/1`)

font_type/1: PREDICATE

Usage 1: `font_type(+Font)`

- *Description:* Indicates the `Font` of the widget's text.
- *Call and exit should be compatible with:*
  `+Font` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `font_type(-Font)`

- *Description:* Gets the `Font` of the widget's text.
- *Call and exit should be compatible with:*
  `-Font` is currently instantiated to an atom. (`term_typing:atom/1`)

background_color/1: PREDICATE

Usage 1: `background_color(+Background)`

- *Description:* Indicates the `Background` color. Default to gray.
- *Call and exit should be compatible with:*

  `+Background` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `background_color(-Background)`

- *Description:* Returns the `Background` color.
- *Call and exit should be compatible with:*

  `-Background` is currently instantiated to an atom. (`term_typing:atom/1`)

borderwidth_value/1: PREDICATE

Usage 1: `borderwidth_value(+BorderWidth)`

- *Description:* Indicates the width's border. Default to 2.
- *Call and exit should be compatible with:*

  `+BorderWidth` is a number. (`basic_props:num/1`)

Usage 2: `borderwidth_value(-BorderWidth)`

- *Description:* Gets the width's border.
- *Call and exit should be compatible with:*

  `-BorderWidth` is currently instantiated to an atom. (`term_typing:atom/1`)

foreground_color/1: PREDICATE

Usage 1: `foreground_color(+Foreground)`

- *Description:* Indicates the `Foreground` color. Default to black
- *Call and exit should be compatible with:*

  `+Foreground` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `foreground_color(-Foreground)`

- *Description:* Gets the `Foreground` color.
- *Call and exit should be compatible with:*

  `-Foreground` is currently instantiated to an atom. (`term_typing:atom/1`)

highlightbackground_color/1: PREDICATE

Usage 1: `highlightbackground_color(+Color)`

- *Description:* `Color` specifies the highlight background color. Default to white
- *Call and exit should be compatible with:*

  `+Color` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `highlightbackground_color(-Color)`

- *Description:* Gets the `Color` of the highlight background.
- *Call and exit should be compatible with:*

  `-Color` is currently instantiated to an atom. (`term_typing:atom/1`)

highlight_color/1: PREDICATE

Usage 1: `highlight_color(+Color)`

- *Description:* `Color` specifies the highlight color. Default to white
- *Call and exit should be compatible with:*

  `+Color` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `highlight_color(-Color)`

- *Description:* Gets the `Color` of the highlight.
- *Call and exit should be compatible with:*

  `-Color` is currently instantiated to an atom. (`term_typing:atom/1`)

width_value/1: PREDICATE

Usage 1: `width_value(+Width)`

- *Description:* Specifies the `Width` for the widget. Default to 0
- *Call and exit should be compatible with:*

  `+Width` is an integer. (`basic_props:int/1`)

Usage 2: `width_value(+Width)`

- *Description:* Gets the `Width` specified for the widget.
- *Call and exit should be compatible with:*

  `+Width` is an integer. (`basic_props:int/1`)

relief_type/1: PREDICATE

Usage 1: `relief_type(+Relief)`

- *Description:* Specifies a desired `Relief` for the widget. Default to sunken
- *Call and exit should be compatible with:*

  `+Relief` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `relief_type(-Relief)`

- *Description:* Gets the `Relief` of the widget.
- *Call and exit should be compatible with:*

  `-Relief` is currently instantiated to an atom. (`term_typing:atom/1`)

side_type/1: PREDICATE

Usage 1: `side_type(+Side)`

- *Description:* Specifies which `Side` of the master, the slave(s) will be packed against. Must be left, right, top or bottom. Defaults to top
- *Call and exit should be compatible with:*

  `+Side` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `side_type(-Side)`

- *Description:* Gets the position of the canvas.
- *Call and exit should be compatible with:*

  `-Side` is currently instantiated to an atom. (`term_typing:atom/1`)

expand_value/1: PREDICATE

Usage 1: `expand_value(+Value)`

- *Description:* Specifies whether the slaves should be expanded to consume extra space in their master. `Value` may have any proper boolean value, such as 1 or 0. Defaults to 0
- *Call and exit should be compatible with:*

  `+Value` is an integer. (`basic_props:int/1`)

Usage 2: `expand_value(-Value)`

- *Description:* Gets the boolean value which indicates if the slaves should be expanded or no.
- *Call and exit should be compatible with:*

  `-Value` is an integer. (`basic_props:int/1`)

fill_type/1: PREDICATE

Usage 1: `fill_type(+Option)`

- *Description:* If a slave's parcel is larger than its requested dimensions, this option may be used to stretch the slave. `Option` must have one of the following values: none (this is the default), x, y, both
- *Call and exit should be compatible with:*

  `+Option` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `fill_type(-Option)`

- *Description:* Gets the fill value of the canvas
- *Call and exit should be compatible with:*

  `-Option` is currently instantiated to an atom. (`term_typing:atom/1`)

padx_value/1: PREDICATE

Usage 1: `padx_value(+Amount)`

- *Description:* `Amount` specifies how much horizontal external padding to leave on each side of the slave(s). Amount defaults to 0
- *Call and exit should be compatible with:*

  `+Amount` is an integer. (`basic_props:int/1`)

Usage 2: `padx_value(-Amount)`

- *Description:* Gets the `Amount` which specifies how much horizontal external padding to leave on each side of the slaves.
- *Call and exit should be compatible with:*

  `-Amount` is an integer. (`basic_props:int/1`)

pady_value/1: PREDICATE

Usage 1: `pady_value(+Amount)`

- *Description:* `Amount` specifies how much vertical external padding to leave on each side of the slave(s). Amount defaults to 0
- *Call and exit should be compatible with:*

  `+Amount` is an integer. (`basic_props:int/1`)

Usage 2: `pady_value(-Amount)`

- *Description:* Gets the `Amount` which specifies how much vertical external padding to leave on each side of the slaves.
- *Call and exit should be compatible with:*

  `-Amount` is an integer. (`basic_props:int/1`)

row_value/1: PREDICATE

Usage 1: `row_value(+Row)`

- *Description:* Indicates the `Row` in which the widget should be allocated.
- *Call and exit should be compatible with:*

  `+Row` is an integer. (`basic_props:int/1`)

Usage 2: `row_value(-Row)`

- *Description:* Gets the `Row` in which the widget is allocated.
- *Call and exit should be compatible with:*

  `-Row` is an integer. (`basic_props:int/1`)

rowspan_value/1: PREDICATE

Usage 1: `rowspan_value(+Row)`

- *Description:* Indicates the number of `Row` which are going to be occupied in the grid.
- *Call and exit should be compatible with:*

  `+Row` is an integer. (`basic_props:int/1`)

Usage 2: `rowspan_value(-Row)`

- *Description:* Gets the number of `Row` which are occupied by the widget in the grid.
- *Call and exit should be compatible with:*

  `-Row` is an integer. (`basic_props:int/1`)

column_value/1: PREDICATE

Usage 1: `column_value(+Column)`

- *Description:* Indicates the `Column` in which the widget should be allocated.
- *Call and exit should be compatible with:*

  `+Column` is an integer. (`basic_props:int/1`)

Usage 2: `column_value(-Column)`

- *Description:* Gets the `Column` in which the widget is allocated.
- *Call and exit should be compatible with:*

  `-Column` is an integer. (`basic_props:int/1`)

columnspan_value/1: PREDICATE

Usage 1: `columnspan_value(+Column)`

- *Description:* Indicates the number of `Column` which are going to be occupied in the grid.

– *Call and exit should be compatible with:*

`+Column` is an integer. (`basic_props:int/1`)

Usage 2: `columnspan_value(-Column)`

– *Description:* Gets the number of `Column` which are occupied by the widget in the grid.

– *Call and exit should be compatible with:*

`-Column` is an integer. (`basic_props:int/1`)

event_type_widget/1: PREDICATE

Usage 1: `event_type_widget(+EventType)`

– *Description:* The event `EventType` is going to be manage by the interface.

– *Call and exit should be compatible with:*

`+EventType` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `event_type_widget(-EventType)`

– *Description:* Gets the event `EventType` which is going to be manage by the interface.

– *Call and exit should be compatible with:*

`-EventType` is currently instantiated to an atom. (`term_typing:atom/1`)

action_widget/3: PREDICATE

Usage 1: `action_widget(+Input,+Output,+Term)`

– *Description:* Executes `Term` with `Input` value and `Output` variable.

– *Call and exit should be compatible with:*

`+Input` is currently instantiated to an atom. (`term_typing:atom/1`)

`+Output` is currently instantiated to an atom. (`term_typing:atom/1`)

`+Term` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `action_widget(+Input,+Output,-Term)`

– *Description:* `Term` is associated to the action of the object indicated with the operacion *event_type_widget*.

– *Call and exit should be compatible with:*

`+Input` is currently instantiated to an atom. (`term_typing:atom/1`)

`+Output` is currently instantiated to an atom. (`term_typing:atom/1`)

`-Term` is currently instantiated to an atom. (`term_typing:atom/1`)

action_widget/1: PREDICATE

Usage 1: `action_widget(+Term)`

– *Description:* `Term` is going to be associated to the action of the object indicated with the operacion *event_type_widget*.

– *Call and exit should be compatible with:*

`+Term` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `action_widget(-Term)`

- *Description:* `Term` is associated to the action of the object indicated with the operacion *event_type_widget*.
- *Call and exit should be compatible with:*

  `-Term` is currently instantiated to an atom. (`term_typing:atom/1`)

creation_options/1: PREDICATE

Usage: `creation_options(-OptionsList)`

- *Description:* Creates a list with the options supported by the widget.
- *Call and exit should be compatible with:*

  `-OptionsList` is a list. (`basic_props:list/1`)

creation_position/1: PREDICATE

Usage: `creation_position(-OptionsList)`

- *Description:* Creates a list with the options supported by the pack command.
- *Call and exit should be compatible with:*

  `-OptionsList` is a list. (`basic_props:list/1`)

creation_position_grid/1: PREDICATE

Usage: `creation_position_grid(-OptionsList)`

- *Description:* Creates a list with the options supported by the grid command.
- *Call and exit should be compatible with:*

  `-OptionsList` is a list. (`basic_props:list/1`)

creation_bind/1: PREDICATE

Usage: `creation_bind(-BindList)`

- *Description:* Creates a list with the event to be manage and the action associated to this event.
- *Call and exit should be compatible with:*

  `-BindList` is a list. (`basic_props:list/1`)

113 menu_class (library)

113.1 Usage and interface (menu_class)

- **Library usage:**
  `:- use_module(library(menu_class)).`
- **Exports:**
  - *Predicates:*
    `name_menu/1`, `menu_data/1`, `label_value/1`, `tearoff_value/1`, `tcl_name/1`, `creation_options/1`, `creation_options_entry/1`, `creation_menu_name/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `tcltk_obj/window_class`, `tcltk_obj/menu_entry_class`, `tcltk/tcltk`, `tcltk/tcltk_low_level`, `lists`.

113.2 Documentation on exports (menu_class)

name_menu/1: PREDICATE

Usage: `name_menu(+Name)`

- *Description:* Indicates the `Name` of the menubutton associated.
- *Call and exit should be compatible with:*
  `+Name` is currently instantiated to an atom. (`term_typing:atom/1`)

menu_data/1: PREDICATE

Usage 1: `menu_data(+Menu)`

- *Description:* `Menu` posted when cascade entry is invoked.
- *Call and exit should be compatible with:*
  `+Menu` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `menu_data(-Menu)`

- *Description:* Gets the `Menu` asociated to the cascade entry.
- *Call and exit should be compatible with:*
  `-Menu` is currently instantiated to an atom. (`term_typing:atom/1`)

label_value/1: PREDICATE

Usage 1: `label_value(+Value)`

- *Description:* `Value` specifies a string to be displayed as an identifying label in the menu entry.
- *Call and exit should be compatible with:*
  `+Value` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `label_value(-Value)`

- *Description:* Gets the string which identify the menu entry.
- *Call and exit should be compatible with:*

  `-Value` is currently instantiated to an atom. (`term_typing:atom/1`)

tearoff_value/1: PREDICATE

Usage 1: `tearoff_value(+Tearoff)`

- *Description:* `Tearoff` must have a proper boolean value, which specifies wheter or not the menu should include a tear-off entry at the top. Defaults to 1.
- *Call and exit should be compatible with:*

  `+Tearoff` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `tearoff_value(-Tearoff)`

- *Description:* Gets the `Tearoff` value
- *Call and exit should be compatible with:*

  `-Tearoff` is currently instantiated to an atom. (`term_typing:atom/1`)

tcl_name/1: PREDICATE

Usage: `tcl_name(-Widget)`

- *Description:* Specifies the name of the `Widget`. In this case is menu.
- *Call and exit should be compatible with:*

  `-Widget` is currently instantiated to an atom. (`term_typing:atom/1`)

creation_options/1: PREDICATE

Usage: `creation_options(-OptionsList)`

- *Description:* Creates a list with the options supported by the menu.
- *Call and exit should be compatible with:*

  `-OptionsList` is a list. (`basic_props:list/1`)

creation_options_entry/1: PREDICATE

Usage: `creation_options_entry(-OptionsList)`

- *Description:* Creates a list with the options of the menu entry.
- *Call and exit should be compatible with:*

  `-OptionsList` is a list. (`basic_props:list/1`)

creation_menu_name/1: PREDICATE

Usage: `creation_menu_name(-OptionsList)`

- *Description:* Creates a list with the name of the menu.
- *Call and exit should be compatible with:*

  `-OptionsList` is a list. (`basic_props:list/1`)

114 canvas_class (library)

114.1 Usage and interface (canvas_class)

- **Library usage:**
  `:- use_module(library(canvas_class)).`
- **Exports:**
  - *Predicates:*
    `canvas_class/0`, `canvas_class/1`, `destructor/0`, `show/0`, `hide_/0`, `width_value/1`, `height_value/1`, `side_type/1`, `expand_value/1`, `fill_type/1`, `padx_value/1`, `pady_value/1`.
  - *Regular Types:*
    `shape/1`, `option/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `tcltk_obj/window_class`, `tcltk_obj/shape_class`, `system`, `strings`, `lists`, `tcltk/tcltk`, `tcltk/tcltk_low_level`.

114.2 Documentation on exports (canvas_class)

shape/1: REGTYPE

Each item type is characterized in two ways: first, the form of the create command used to create instances of the type; and second, a set of configuration options for items of that type, which may be used in the create and itemconfigure widget commands.

Usage: `shape(S)`

- *Description:* `S` is a reference to one type of the items supported by canvas widgets.

option/1: REGTYPE

Usage: `option(O)`

- *Description:* `O` is *hidden* if the Shape is not visible or *shown* if its visible.

canvas_class/0: PREDICATE

Usage:

- *Description:* Creates a new interpreter, asserting the predicate *interp(I)* and the canvas object.

canvas_class/1: PREDICATE

Usage: `canvas_class(+ItemsList)`

- *Description:* Adds items of the list to the canvas object.
- *Call and exit should be compatible with:*
  `+ItemsList` is a list. (`basic_props:list/1`)

destructor/0: PREDICATE

Usage:

– *Description:* Deletes the shapes of the canvas object and the object.

show/0: PREDICATE

Usage:

– *Description:* Adds shapes to the canvas object.

hide_/0: PREDICATE

Usage:

– *Description:* Hides shapes from the canvas object.

width_value/1: PREDICATE

Usage 1: `width_value(+Width)`

– *Description:* Sets the `Width` of the canvas. Default 100.

– *Call and exit should be compatible with:*

`+Width` is a number. (`basic_props:num/1`)

Usage 2: `width_value(-Width)`

– *Description:* Gets the `Width` of the canvas.

– *Call and exit should be compatible with:*

`-Width` is a number. (`basic_props:num/1`)

height_value/1: PREDICATE

Usage 1: `height_value(+Height)`

– *Description:* Sets the `Height` of the canvas. Default 50.

– *Call and exit should be compatible with:*

`+Height` is a number. (`basic_props:num/1`)

Usage 2: `height_value(-Height)`

– *Description:* Gets the `Height` of the canvas.

– *Call and exit should be compatible with:*

`-Height` is a number. (`basic_props:num/1`)

side_type/1: PREDICATE

Usage 1: `side_type(+Side)`

– *Description:* Specifies which `Side` of the master, the slave(s) will be packed against. Must be left, right, top or bottom. Defaults to top.

– *Call and exit should be compatible with:*

`+Side` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `side_type(-Side)`

– *Description:* Gets the `Side` of the canvas.

– *Call and exit should be compatible with:*

`-Side` is currently instantiated to an atom. (`term_typing:atom/1`)

expand_value/1: PREDICATE

Usage 1: `expand_value(+Value)`

- *Description:* Specifies whether the slaves should be expanded to consume extra space in their master. `Value` may have any proper boolean value, such as 1 or no. Defaults to 0
- *Call and exit should be compatible with:*

  `+Value` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `expand_value(-Value)`

- *Description:* Gets the boolean `Value` which indicates if the slaves should be expanded or no.
- *Call and exit should be compatible with:*

  `-Value` is currently instantiated to an atom. (`term_typing:atom/1`)

fill_type/1: PREDICATE

Usage 1: `fill_type(+Option)`

- *Description:* If a slave's parcel is larger than its requested dimensions, this option may be used to stretch the slave. Style must have one of the following values: none (this is the default), x, y, both
- *Call and exit should be compatible with:*

  `+Option` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `fill_type(-Option)`

- *Description:* Gets the fill value of the canvas
- *Call and exit should be compatible with:*

  `-Option` is currently instantiated to an atom. (`term_typing:atom/1`)

padx_value/1: PREDICATE

Usage 1: `padx_value(+Amount)`

- *Description:* `Amount` specifies how much horizontal external padding to leave on each side of the slave(s). Amount defaults to 0.
- *Call and exit should be compatible with:*

  `+Amount` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `padx_value(-Amount)`

- *Description:* Gets the `Amount` which specifies how much horizontal external padding to leave on each side of the slaves.
- *Call and exit should be compatible with:*

  `-Amount` is currently instantiated to an atom. (`term_typing:atom/1`)

pady_value/1: PREDICATE

Usage 1: `pady_value(+Amount)`

- *Description:* `Amount` specifies how much vertical external padding to leave on each side of the slave(s). Amount defaults to 0.
- *Call and exit should be compatible with:*

  `+Amount` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `pady_value(-Amount)`

- *Description:* Gets the `Amount` which specifies how much vertical external padding to leave on each side of the slaves.
- *Call and exit should be compatible with:*

  `-Amount` is currently instantiated to an atom. (`term_typing:atom/1`)

115 button_class (library)

115.1 Usage and interface (button_class)

- **Library usage:**
  `:- use_module(library(button_class)).`
- **Exports:**
  - *Predicates:*
    `command_button/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

115.2 Documentation on exports (button_class)

command_button/1: PREDICATE

Usage 1: `command_button(+Command)`

- *Description:* Sets a Tcl `Command` to be associated with the button. This `Command` is typically invoked when mouse button 1 is released over the button window.
- *Call and exit should be compatible with:*
  `+Command` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `command_button(-Command)`

- *Description:* Gets the Tcl `Command` associated with the button.
- *Call and exit should be compatible with:*
  `-Command` is currently instantiated to an atom. (`term_typing:atom/1`)

116 checkbutton_class (library)

116.1 Usage and interface (checkbutton_class)

- **Library usage:**
  `:- use_module(library(checkbutton_class)).`
- **Exports:**
  - *Predicates:*
    `variable_value/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

116.2 Documentation on exports (checkbutton_class)

variable_value/1: PREDICATE

Usage 1: `variable_value(+Variable)`

- *Description:* Sets the value of global `Variable` to indicate whether or not this button is selected.
- *Call and exit should be compatible with:*
  `+Variable` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `variable_value(-Variable)`

- *Description:* Gets the value of global `Variable` which indicates if the button is selected.
- *Call and exit should be compatible with:*
  `-Variable` is currently instantiated to an atom. (`term_typing:atom/1`)

117 radiobutton_class (library)

117.1 Usage and interface (radiobutton_class)

- **Library usage:**
  `:- use_module(library(radiobutton_class)).`
- **Exports:**
  - *Predicates:*
    `variable_value/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

117.2 Documentation on exports (radiobutton_class)

variable_value/1: PREDICATE

Usage 1: `variable_value(+Variable)`

- *Description:* Specifies the value of global `Variable` to set whenever this button is selected.
- *Call and exit should be compatible with:*
  `+Variable` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `variable_value(-Variable)`

- *Description:* Gets the value of global `Variable` which indicates if this button is selected.
- *Call and exit should be compatible with:*
  `-Variable` is currently instantiated to an atom. (`term_typing:atom/1`)

118 entry_class (library)

118.1 Usage and interface (entry_class)

- **Library usage:**
  `:- use_module(library(entry_class)).`
- **Exports:**
  - *Predicates:*
    `textvariable_entry/1`, `textvariablevalue_string/1`, `textvariablevalue_number/1`, `justify_entry/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `lists`, `tcltk/examples/tk_test_aux`, `tcltk/tcltk`.

118.2 Documentation on exports (entry_class)

textvariable_entry/1: PREDICATE

Usage 1: `textvariable_entry(+Variable)`

- *Description:* `Variable` specifies the name of the Tcl variable
- *Call and exit should be compatible with:*
  `+Variable` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `textvariable_entry(-Variable)`

- *Description:* Gets the name of the Tcl `Variable` associated to the entry
- *Call and exit should be compatible with:*
  `-Variable` is currently instantiated to an atom. (`term_typing:atom/1`)

textvariablevalue_string/1: PREDICATE

Usage 1: `textvariablevalue_string(+Value)`

- *Description:* Specifies the `Value` of the Tcl variable associated to the entry.
- *Call and exit should be compatible with:*
  `+Value` is a number. (`basic_props:num/1`)

Usage 2: `textvariablevalue_string(-Value)`

- *Description:* `Value` is the value of the Tcl variable associated to the entry.
- *Call and exit should be compatible with:*
  `-Value` is a number. (`basic_props:num/1`)

textvariablevalue_number/1: PREDICATE

Usage 1: `textvariablevalue_number(+Value)`

- *Description:* Specifies the `Value` of the Tcl variable associated to the entry.

– *Call and exit should be compatible with:*
`+Value` is a number. (`basic_props:num/1`)

Usage 2: `textvariablevalue_number(-Value)`

– *Description:* `Value` is the value of the Tcl variable associated to the entry.
– *Call and exit should be compatible with:*
`-Value` is a number. (`basic_props:num/1`)

justify_entry/1: PREDICATE

Usage 1: `justify_entry(+How)`

– *Description:* `How` specifies how to justify the text in the entry. `How` must be one of the values left, right or center. This option defaluts to left.
– *Call and exit should be compatible with:*
`+How` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `justify_entry(-How)`

– *Description:* Gets `How` is justified the text.
– *Call and exit should be compatible with:*
`-How` is currently instantiated to an atom. (`term_typing:atom/1`)

119 label_class (library)

119.1 Usage and interface (label_class)

- **Library usage:**
  `:- use_module(library(label_class)).`
- **Exports:**
  - *Predicates:*
    `textvariable_label/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

119.2 Documentation on exports (label_class)

textvariable_label/1: PREDICATE

No further documentation available for this predicate.

120 menubutton_class (library)

120.1 Usage and interface (menubutton_class)

- **Library usage:**
  `:- use_module(library(menubutton_class)).`
- **Exports:**
  - *Predicates:*
    `menu_name/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `lists`.

120.2 Documentation on exports (menubutton_class)

menu_name/1: PREDICATE

Usage 1: `menu_name(+Menu)`

- *Description:* `Menu` posted when menubutton is clicked.
- *Call and exit should be compatible with:*
  `+Menu` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `menu_name(-Menu)`

- *Description:* Gets the name of the `Menu` asociated to the menubutton.
- *Call and exit should be compatible with:*
  `-Menu` is currently instantiated to an atom. (`term_typing:atom/1`)

121 menu_entry_class (library)

121.1 Usage and interface (menu_entry_class)

- **Library usage:**
  `:- use_module(library(menu_entry_class)).`
- **Exports:**
  - *Predicates:*
    `set_name/1`, `set_action/1`, `label_value/1`, `menu_name/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `tcltk_obj/menu_class`, `lists`.

121.2 Documentation on exports (menu_entry_class)

set_name/1: PREDICATE

Usage: `set_name(+Name)`

- *Description:* `Name` of the menubutton associated.
- *Call and exit should be compatible with:*
  `+Name` is currently instantiated to an atom. (`term_typing:atom/1`)

set_action/1: PREDICATE

Usage: `set_action(+Predicate)`

- *Description:* Specifies `Predicate` asociated to the menu entry.
- *Call and exit should be compatible with:*
  `+Predicate` is currently instantiated to an atom. (`term_typing:atom/1`)

label_value/1: PREDICATE

Usage 1: `label_value(+Value)`

- *Description:* `Value` specifies a value to be displayed as an identifying label in the menu entry.
- *Call and exit should be compatible with:*
  `+Value` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `label_value(-Value)`

- *Description:* Gets the string which identify label in the menu entry.
- *Call and exit should be compatible with:*
  `-Value` is currently instantiated to an atom. (`term_typing:atom/1`)

menu_name/1: PREDICATE

Usage 1: `menu_name(+Menu)`

- *Description:* `Menu` posted when cascade entry is invoked.
- *Call and exit should be compatible with:*

  `+Menu` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `menu_name(-Menu)`

- *Description:* Gets the `Menu` asociated to the cascade entry.
- *Call and exit should be compatible with:*

  `-Menu` is currently instantiated to an atom. (`term_typing:atom/1`)

122 shape_class (library)

122.1 Usage and interface (shape_class)

- **Library usage:**
  `:- use_module(library(shape_class)).`
- **Exports:**
  - *Predicates:*
    `bg_color/1`, `border_width/1`, `shape_class/0`, `shape_class/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `tcltk_obj/canvas_class`.

122.2 Documentation on exports (shape_class)

bg_color/1: PREDICATE

Usage 1: `bg_color(+BackgroundColor)`

- *Description:* `Background Color` specifies the color to use for drawing the shape's outline. This option defaults to black.
- *Call and exit should be compatible with:*
  `+BackgroundColor` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `bg_color(-BackgroundColor)`

- *Description:* Gets the shape `Background Color`.
- *Call and exit should be compatible with:*
  `-BackgroundColor` is currently instantiated to an atom. (`term_typing:atom/1`)

border_width/1: PREDICATE

Usage 1: `border_width(+Width)`

- *Description:* Specifies the `Width` that the canvas widget should request from its geometry manager.
- *Call and exit should be compatible with:*
  `+Width` is a number. (`basic_props:num/1`)

Usage 2: `border_width(-Width)`

- *Description:* Gets the `Width` of the canvas widget.
- *Call and exit should be compatible with:*
  `-Width` is a number. (`basic_props:num/1`)

shape_class/0: PREDICATE

Usage:

- *Description:* Creates a new shape object.

shape_class/1: PREDICATE

Usage: `shape_class(+ShapeList)`

- *Description:* Adds shapes of the list to the canvas object.
- *Call and exit should be compatible with:*

  `+ShapeList` is a list. (`basic_props:list/1`)

123 arc_class (library)

123.1 Usage and interface (arc_class)

- **Library usage:**
  `:- use_module(library(arc_class)).`
- **Exports:**
  - *Predicates:*
    `coord/4`, `width/1`, `height/1`, `center/2`, `angle_start/1`, `style_type/1`, `outline_color/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

123.2 Documentation on exports (arc_class)

coord/4: PREDICATE

Usage: `coord(+X1,+Y1,+X2,+Y2)`

- *Description:* `X1`, `Y1`, `X2`, and `Y2` give the coordinates of two diagonally opposite corners of a rectangular region enclosing the oval that defines the arc.
- *Call and exit should be compatible with:*

`+X1` is an integer.	(`basic_props:int/1`)
`+Y1` is an integer.	(`basic_props:int/1`)
`+X2` is an integer.	(`basic_props:int/1`)
`+Y2` is an integer.	(`basic_props:int/1`)

width/1: PREDICATE

Usage 1: `width(+Width)`

- *Description:* Specifies shape's `Width`.
- *Call and exit should be compatible with:*

`+Width` is an integer.	(`basic_props:int/1`)

Usage 2: `width(-Width)`

- *Description:* Gets shape's `Width`.
- *Call and exit should be compatible with:*

`-Width` is an integer.	(`basic_props:int/1`)

height/1: PREDICATE

Usage 1: `height(+Height)`

- *Description:* Specifies shape's `Height`.

– *Call and exit should be compatible with:*

`+Height` is an integer. (`basic_props:int/1`)

Usage 2: `height(-Height)`

– *Description:* Gets shape's `Height`.

– *Call and exit should be compatible with:*

`-Height` is an integer. (`basic_props:int/1`)

center/2: PREDICATE

Usage 1: `center(+X,+Y)`

– *Description:* Specifies shape's center with `X` and `Y`.

– *Call and exit should be compatible with:*

`+X` is an integer. (`basic_props:int/1`)

`+Y` is an integer. (`basic_props:int/1`)

Usage 2: `center(-X,-Y)`

– *Description:* Gets shape's center with `X` and `Y`.

– *Call and exit should be compatible with:*

`-X` is an integer. (`basic_props:int/1`)

`-Y` is an integer. (`basic_props:int/1`)

angle_start/1: PREDICATE

Usage 1: `angle_start(+Angle)`

– *Description:* `Angle` specifies the beginning of the angular range occupied by the arc. Degrees are given in units of degrees measured counter-clockwise from the 3-o'clock position; it may be either positive or negative.

– *Call and exit should be compatible with:*

`+Angle` is an integer. (`basic_props:int/1`)

Usage 2: `angle_start(-Angle)`

– *Description:* Gets the value of the `Angle`.

– *Call and exit should be compatible with:*

`-Angle` is an integer. (`basic_props:int/1`)

style_type/1: PREDICATE

Usage 1: `style_type(+Style)`

– *Description:* `Style` specifies how to draw the arc. If type is pieslice (the default) then the arc's region is defined by a section of the oval's perimeter plus two line segments, one between the center of the oval and each end of the perimeter section. If type is chord then the arc's region is defined by a section of the oval's perimeter plus a single line segment connecting the two end points of the perimeter section. If type is arc then the arc's region consists of a section of the perimeter alone. In this last case the -fill option is ignored.

– *Call and exit should be compatible with:*

`+Style` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `style_type(-Style)`

- *Description:* Gets the `Style` of the arc.
- *Call and exit should be compatible with:*

  `-Style` is currently instantiated to an atom. (`term_typing:atom/1`)

outline_color/1: PREDICATE

Usage 1: `outline_color(+Color)`

- *Description:* `Color` specifies the color used for drawing the arc's outline. This option defaults to black.
- *Call and exit should be compatible with:*

  `+Color` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `outline_color(-Color)`

- *Description:* It gets arc's outline `Color`.
- *Call and exit should be compatible with:*

  `-Color` is currently instantiated to an atom. (`term_typing:atom/1`)

124 oval_class (library)

124.1 Usage and interface (oval_class)

- **Library usage:**
  `:- use_module(library(oval_class)).`
- **Exports:**
  - *Predicates:*
    `coord/4`, `width/1`, `height/1`, `center/2`, `outline_color/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

124.2 Documentation on exports (oval_class)

coord/4: PREDICATE

Usage: `coord(+X1,+Y1,+X2,+Y2)`

- *Description:* `X1`, `Y1`, `X2`, and `Y2` give the coordinates of two diagonally opposite corners of a rectangular region enclosing the oval.
- *Call and exit should be compatible with:*
  `+X1` is an integer. (`basic_props:int/1`)
  `+Y1` is an integer. (`basic_props:int/1`)
  `+X2` is an integer. (`basic_props:int/1`)
  `+Y2` is an integer. (`basic_props:int/1`)

width/1: PREDICATE

Usage 1: `width(+Width)`

- *Description:* Specifies shape's `Width`.
- *Call and exit should be compatible with:*
  `+Width` is an integer. (`basic_props:int/1`)

Usage 2: `width(-Width)`

- *Description:* Gets shape's `Width`.
- *Call and exit should be compatible with:*
  `-Width` is an integer. (`basic_props:int/1`)

height/1: PREDICATE

Usage 1: `height(+Height)`

- *Description:* Specifies shape's `Heigh`.
- *Call and exit should be compatible with:*
  `+Height` is an integer. (`basic_props:int/1`)

Usage 2: `height(-Height)`

– *Description:* Gets shape's `Height`.

– *Call and exit should be compatible with:*

`-Height` is an integer. (`basic_props:int/1`)

center/2: PREDICATE

Usage 1: `center(+X,+Y)`

– *Description:* Specifies shape's center with `X` and `Y`.

– *Call and exit should be compatible with:*

`+X` is an integer. (`basic_props:int/1`)

`+Y` is an integer. (`basic_props:int/1`)

Usage 2: `center(-X,-Y)`

– *Description:* Gets shape's center with `X` and `Y`.

– *Call and exit should be compatible with:*

`-X` is an integer. (`basic_props:int/1`)

`-Y` is an integer. (`basic_props:int/1`)

outline_color/1: PREDICATE

Usage 1: `outline_color(+Color)`

– *Description:* `Color` specifies the color to be used for drawing the oval's outline. This option defaults to black.

– *Call and exit should be compatible with:*

`+Color` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `outline_color(-Color)`

– *Description:* Gets oval's outline `Color`.

– *Call and exit should be compatible with:*

`-Color` is currently instantiated to an atom. (`term_typing:atom/1`)

125 poly_class (library)

125.1 Usage and interface (poly_class)

- **Library usage:**
  `:- use_module(library(poly_class)).`
- **Exports:**
  - *Predicates:*
    `vertices/1`, `outline_color/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `lists`.

125.2 Documentation on exports (poly_class)

vertices/1: PREDICATE

Usage 1: `vertices(+ListofPoints)`

- *Description:* The arguments of the list specify the coordinates for three or more points that define a closed polygon. The first and last points may be the same. After the coordinates there may be any number of option-value pairs, each of which sets one of the configu- ration options for the item.
- *Call and exit should be compatible with:*
  `+ListofPoints` is a list. (`basic_props:list/1`)

Usage 2: `vertices(-ListofPoints)`

- *Description:* Gets the list of vertices of the polygon.
- *Call and exit should be compatible with:*
  `-ListofPoints` is a list. (`basic_props:list/1`)

outline_color/1: PREDICATE

Usage 1: `outline_color(+Color)`

- *Description:* `Color` specifies the color to be used for drawing the polygon's outline. This option defaults to black.
- *Call and exit should be compatible with:*
  `+Color` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `outline_color(-Color)`

- *Description:* Gets poly's outline `Color`.
- *Call and exit should be compatible with:*
  `-Color` is currently instantiated to an atom. (`term_typing:atom/1`)

126 line_class (library)

126.1 Usage and interface (line_class)

- **Library usage:**
  `:- use_module(library(line_class)).`
- **Exports:**
  - *Predicates:*
    `vertices/1`, `arrowheads/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`, `lists`.

126.2 Documentation on exports (line_class)

vertices/1: PREDICATE

Usage 1: `vertices(+ListofPoints)`

- *Description:* The arguments of the list specify the coordinates for two or more points that describe a serie of connected line segments.
- *Call and exit should be compatible with:*
  `+ListofPoints` is a list. (`basic_props:list/1`)

Usage 2: `vertices(-ListofPoints)`

- *Description:* Gets the list of points of the line.
- *Call and exit should be compatible with:*
  `-ListofPoints` is a list. (`basic_props:list/1`)

arrowheads/1: PREDICATE

Usage 1: `arrowheads(+Where)`

- *Description:* `Where` indicates whether or not arrowheads are to be drawn at one or both ends of the line. `Where` must have one of the next values: none (for no arrowheads), first (for an arrowhead at the first point of the line), last (for an arrowhead at the last point of the line), or both (for arrowheads at both ends). This option defaults to none.
- *Call and exit should be compatible with:*
  `+Where` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `arrowheads(-Where)`

- *Description:* Gets position of the arrowheads.
- *Call and exit should be compatible with:*
  `-Where` is currently instantiated to an atom. (`term_typing:atom/1`)

127 text_class (library)

127.1 Usage and interface (text_class)

- **Library usage:**
  `:- use_module(library(text_class)).`
- **Exports:**
  - *Predicates:*
    `coord/2`, `point/2`, `text_characters/1`, `anchor/1`, `font_type/1`, `justify_text/1`.
- **Other modules used:**
  - *System library modules:*
    `objects/objects_rt`.

127.2 Documentation on exports (text_class)

coord/2: PREDICATE

Usage: `coord(+X,+Y)`

- *Description:* `X` and `Y` specify the coordinates of a point used to position the text on the display.
- *Call and exit should be compatible with:*
  `+X` is an integer. (`basic_props:int/1`)
  `+Y` is an integer. (`basic_props:int/1`)

point/2: PREDICATE

Usage: `point(+X,+Y)`

- *Description:* `X` and `Y` change the coordinates of a point used to position the text on the display.
- *Call and exit should be compatible with:*
  `+X` is an integer. (`basic_props:int/1`)
  `+Y` is an integer. (`basic_props:int/1`)

text_characters/1: PREDICATE

Usage 1: `text_characters(+Text)`

- *Description:* `Text` specifies the characters to be displayed in the text item. This option defaults to an empty string.
- *Call and exit should be compatible with:*
  `+Text` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `text_characters(-Text)`

- *Description:* Gets the text displayed in the text item.
- *Call and exit should be compatible with:*
  `-Text` is currently instantiated to an atom. (`term_typing:atom/1`)

anchor/1: PREDICATE

Usage 1: `anchor(+AnchorPos)`

- *Description:* `AnchorPos` tells how to position the text relative to the positioning point for the text. This option defaluts to center.
- *Call and exit should be compatible with:*

  `+AnchorPos` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `anchor(-AnchorPos)`

- *Description:* Gets the position of the text relative to the positioning point.
- *Call and exit should be compatible with:*

  `-AnchorPos` is currently instantiated to an atom. (`term_typing:atom/1`)

font_type/1: PREDICATE

Usage 1: `font_type(+Font)`

- *Description:* `Font` specifies the font to use for the text item. This option defaluts to arial.
- *Call and exit should be compatible with:*

  `+Font` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `font_type(-Font)`

- *Description:* Gets the value of the `Font` used for the text item.
- *Call and exit should be compatible with:*

  `-Font` is currently instantiated to an atom. (`term_typing:atom/1`)

justify_text/1: PREDICATE

Usage 1: `justify_text(+How)`

- *Description:* `How` specifies how to justify the text within its bounding region. `How` must be one of the values left, right or center. This option defaluts to left.
- *Call and exit should be compatible with:*

  `+How` is currently instantiated to an atom. (`term_typing:atom/1`)

Usage 2: `justify_text(-How)`

- *Description:* Gets `How` is justified the text.
- *Call and exit should be compatible with:*

  `-How` is currently instantiated to an atom. (`term_typing:atom/1`)

128 The PiLLoW Web programming library

Author(s): Daniel Cabeza, Manuel Hermenegildo, clip@clip.dia.fi.upm.es, http://www.clip.dia.fi.upm.es/, The CLIP Group, School of Computer Science, Technical University of Madrid.

This package implements the PiLLoW library [CHV96a]. The following three chapters document, respectively, the predicates for HTML/XML/CGI programming, the predicate for HTTP conectivity, and the types used in the definition of the predicates (key for fully understanding the other predicates). You can find a paper and some additional information in the library/pillow/doc directory of the distribution, and in the WWW at http://clip.dia.fi.upm.es/Software/pillow/pillow.html. There is also a *PiLLoW on-line tutorial* (slides) at http://clip.dia.fi.upm.es/logalg/slides/C_pillow/C_pillow.html which illustrates the basic features and provides a number of examples of PiLLoW use.

128.1 Installing PiLLoW

To correctly install PiLLoW, first, make sure you downloaded the right version of PiLLoW (there are different versions for different LP/CLP systems; the version that comes with Ciao is of course the right one for Ciao). Then, please follow these steps:

1. Copy the files in the images directory to a WWW accessible directory in your server.
2. Edit the file icon_address.pl and change the fact to point to the URL to be used to access the images above.
3. In the Ciao system the files are in the correct place, in other systems copy the files pillow.pl and icon_address.pl to a suitable directory so that your Prolog system will find them.

128.2 Usage and interface (pillow)

- **Library usage:**
  ```
  :- use_package(pillow).
  ```
  or
  ```
  :- module(...,...,[pillow]).
  ```
- **New operators defined:**
  $/2 [150,xfx], $/1 [150,fx].
- **Other modules used:**
  - *System library modules:*
    pillow/http, pillow/html.

129 HTML/XML/CGI programming

Author(s): Daniel Cabeza, Manuel Hermenegildo, Sacha Varma.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#131 (2001/10/29, 20:47:56 CET)

This module implements the predicates of the PiLLoW package related to HTML/ XML generation and parsing, CGI and form handlers programming, and in general all the predicates which do not imply the use of the HTTP protocol.

129.1 Usage and interface (`html`)

- **Library usage:**
  `:- use_module(library(html)).`
- **Exports:**
  - *Predicates:*
    `output_html/1`, `html2terms/2`, `xml2terms/2`, `html_template/3`, `html_report_error/1`, `get_form_input/1`, `get_form_value/3`, `form_empty_value/1`, `form_default/3`, `set_cookie/2`, `get_cookies/1`, `url_query/2`, `my_url/1`, `url_info/2`, `url_info_relative/3`, `form_request_method/1`, `icon_address/2`, `html_protect/1`, `http_lines/3`.
  - *Multifiles:*
    `html_expansion/2`.
- **Other modules used:**
  - *System library modules:*
    `strings`, `lists`, `system`, `pillow/pillow_aux`, `pillow/pillow_types`.

129.2 Documentation on exports (`html`)

output_html/1: PREDICATE

`output_html(HTMLTerm)`

Outputs `HTMLTerm`, interpreted as an `html_term/1`, to current output stream.

html2terms/2: PREDICATE

`html2terms(String,Terms)`

`String` is a character list containing HTML code and `Terms` is its prolog structured representation.

Usage 1: `html2terms(-string,+html_term)`

- *Description:* Translates an HTML-term into the HTML code it represents.

Usage 2: `html2terms(+string,?canonic_html_term)`

- *Description:* Translates HTML code into a structured HTML-term.

xml2terms/2: PREDICATE

`xml2terms(String,Terms)`

`String` is a character list containing XML code and `Terms` is its prolog structured representation.

Usage 1: `xml2terms(-string,+html_term)`

– *Description:* Translates a XML-term into the XML code it represents.

Usage 2: `xml2terms(+string,?canonic_xml_term)`

– *Description:* Translates XML code into a structured XML-term.

html_template/3: PREDICATE

`html_template(Chars,Terms,Dict)`

Interprets `Chars` as an HTML template returning in `Terms` the corresponding structured HTML-term, which includes variables, and unifying `Dict` with a dictionary of those variables (an incomplete list of *name=Var* pairs). An HTML template is standard HTML code, but in which "slots" can be defined and given an identifier. These slots represent parts of the HTML code in which other HTML code can be inserted, and are represented in the HTML-term as free variables. There are two kinds of variables in templates:

- Variables representing page contents. A variable with name *name* is defined with the special tag `<V>`*name*`</V>`.
- Variables representing tag attributes. They occur as an attribute or an attribute value starting with _, followed by its name, which must be formed by alphabetic characters.

As an example, suposse the following HTML template:

```
<html>
<body bgcolor=_bgcolor>
<v>content</v>
</body>
</html>
```

The following query in the Ciao toplevel shows how the template is parsed, and the dictionary returned:

```
?- file_to_string('template.html',_S), html_template(_S,Terms,Dict).

Dict = [bgcolor=_A,content=_B|_],
Terms = [env(html,[],["
",env(body,[bgcolor=_A],["
",_B,"
"]),"
"]),"
"] ?

yes
```

If a dictionary with values is supplied at call time, then variables are unified accordingly inside the template:

```
?- file_to_string('template.html',_S),
   html_template(_S,Terms,[content=b("hello world!"),bgcolor="white"]).

Terms = [env(html,[],["
```

```
",env(body,[bgcolor="white"],["
",b("hello world!"),"
"]),"
"]),"
"] ?

yes
```

html_report_error/1: PREDICATE

Usage: `html_report_error(Error)`

– *Description:* Outputs error `Error` as a standard HTML page.

get_form_input/1: PREDICATE

`get_form_input(Dict)`

Translates input from the form (with either the POST or GET methods, and even with CONTENT_TYPE multipart/form-data) to a dictionary `Dict` of *attribute=value* pairs. It translates empty values (which indicate only the presence of an attribute) to the atom `'$empty'`, values with more than one line (from text areas or files) to a list of lines as strings, the rest to atoms or numbers (using `name/2`).

get_form_value/3: PREDICATE

`get_form_value(Dict,Var,Val)`

Unifies `Val` with the value for attribute `Var` in dictionary `Dict`. Does not fail: value is `''` if not found (this simplifies the programming of form handlers when they can be accessed directly).

form_empty_value/1: PREDICATE

Usage: `form_empty_value(Term)`

– *Description:* Checks that `Term`, a value comming from a text area is empty (can have spaces, newlines and linefeeds).

form_default/3: PREDICATE

Usage: `form_default(+Val,+Default,-NewVal)`

– *Description:* Useful when a form is only partially filled, or when the executable can be invoked either by a link or by a form, to set form defaults. If the value of `Val` is empty then `NewVal=Default`, else `NewVal=Val`.

set_cookie/2: PREDICATE

`set_cookie(Name,Value)`

Sets a cookie of name `Name` and value `Value`. Must be invoked before outputting any data, including the `cgi_reply` html-term.

get_cookies/1: PREDICATE

`get_cookies(Cookies)`

Unifies `Cookies` with a dictionary of *attribute=value* pairs of the active cookies for this URL.

url_query/2: PREDICATE

`url_query(Dict,URLArgs)`

Translates a dictionary `Dict` of parameter values into a string `URLArgs` for appending to a URL pointing to a form handler.

my_url/1: PREDICATE

`my_url(URL)`

Unifies `URL` with the Uniform Resource Locator (WWW address) of this cgi executable.

url_info/2: PREDICATE

`url_info(URL,URLTerm)`

Translates a URL `URL` to a Prolog structure `URLTerm` which details its various components, and vice-versa. For now non-HTTP URLs make the predicate fail.

url_info_relative/3: PREDICATE

`url_info_relative(URL,BaseURLTerm,URLTerm)`

Translates a relative URL `URL` which appears in the HTML page refered to by `BaseURLTerm` into `URLTerm`, a Prolog structure containing its absolute parameters. Absolute URLs are translated as with `url_info/2`. E.g.

```
url_info_relative("dadu.html",
                  http('www.foo.com',80,"/bar/scoob.html"), Info)
```

gives `Info = http('www.foo.com',80,"/bar/dadu.html")`.

form_request_method/1: PREDICATE

Usage: `form_request_method(Method)`

- *Description:* Unifies `Method` with the method of invocation of the form handler (`GET` or `POST`).
- *The following properties hold upon exit:*

  `Method` is an atom. (`basic_props:atm/1`)

icon_address/2: PREDICATE

`icon_address(Img,IAddress)`

The PiLLoW image `Img` has URL `IAddress`.

html_protect/1: PREDICATE

`html_protect(Goal)`

Calls `Goal`. If an error occurs during its execution, or it fails, an HTML page is output informing about the incident. Normaly the whole execution of a CGI is protected thus.

Meta-predicate with arguments: `html_protect(goal)`.

Usage:

- *Calls should, and exit will be compatible with:*

  `Goal` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

http_lines/3: PREDICATE

Usage: `http_lines(Lines,String,Tail)`

- *Description:* `Lines` is a list of the lines with occur in `String` until `Tail`. The lines may end UNIX-style or DOS-style in `String`, in `Lines` they have not end of line characters. Suitable to be used in DCGs.
- *Calls should, and exit will be compatible with:*

  `Lines` is a list of `strings`. (`basic_props:list/2`)

  `String` is a string (a list of character codes). (`basic_props:string/1`)

  `Tail` is a string (a list of character codes). (`basic_props:string/1`)

129.3 Documentation on multifiles (`html`)

html_expansion/2: PREDICATE

The predicate is *multifile*.

Usage: `html_expansion(Term,Expansion)`

- *Description:* Hook predicate to define macros. Expand occurrences of `Term` into `Expansion`, in `output_html/1`. Take care to not transform something into itself!

129.4 Other information (`html`)

The code uses input from from L. Naish's forms and F. Bueno's previous Chat interface. Other people who have contributed is (please inform us if we leave out anybody): Markus Fromherz, Samir Genaim.

130 HTTP conectivity

Author(s): Daniel Cabeza.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.3#114 (1999/11/24, 0:57:16 MET)

This module implements the HTTP protocol, which allows retrieving data from HTTP servers.

130.1 Usage and interface (`http`)

- **Library usage:**
  `:- use_module(library(http)).`
- **Exports:**
  - *Predicates:*
    `fetch_url/3`.
- **Other modules used:**
  - *System library modules:*
    `strings`, `lists`, `pillow/pillow_aux`, `pillow/pillow_types`, `pillow/http_ll`.

130.2 Documentation on exports (`http`)

fetch_url/3: PREDICATE

`fetch_url(URL,Request,Response)`

Fetches the document pointed to by `URL` from Internet, using request parameters `Request`, and unifies `Response` with the parameters of the response. Fails on timeout. Note that redirections are not handled automatically, that is, if `Response` contains terms of the form `status(redirection,301,_)` and `location(NewURL)`, the program should in most cases access location `NewURL`.

Usage: `fetch_url(URL,Request,Response)`

- *The following properties should hold at call time:*
  `URL` specifies a URL. (`pillow_types:url_term/1`)
  `Request` is a list of `http_request_params`. (`basic_props:list/2`)
- *The following properties hold upon exit:*
  `Response` is a list of `http_response_params`. (`basic_props:list/2`)

131 PiLLoW types

Author(s): Daniel Cabeza.

Here are defined the regular types used in the documentation of the predicates of the PiLLoW package.

131.1 Usage and interface (pillow_types)

- **Library usage:**
  `:- use_module(library(pillow_types)).`
- **Exports:**
  - *Regular Types:*
    `canonic_html_term/1`, `canonic_xml_term/1`, `html_term/1`, `form_dict/1`, `form_assignment/1`, `form_value/1`, `value_dict/1`, `url_term/1`, `http_request_param/1`, `http_response_param/1`, `http_date/1`, `weekday/1`, `month/1`, `hms_time/1`.

131.2 Documentation on exports (pillow_types)

canonic_html_term/1: REGTYPE

A term representing HTML code in canonical, structured way. It is a list of terms defined by the following predicate:

```
canonic_html_item(comment(S)) :-
        string(S).
canonic_html_item(declare(S)) :-
        string(S).
canonic_html_item(env(Tag,Atts,Terms)) :-
        atm(Tag),
        list(Atts,tag_attrib),
        canonic_html_term(Terms).
canonic_html_item($(Tag,Atts)) :-
        atm(Tag),
        list(Atts,tag_attrib).
canonic_html_item(S) :-
        string(S).
tag_attrib(Att) :-
        atm(Att).
tag_attrib(Att=Val) :-
        atm(Att),
        string(Val).
```

Each structure represents one HTML construction:

env(*tag*,*attribs*,*terms*)
: An HTML environment, with name *tag*, list of attributes *attribs* and contents *terms*.

$(*tag*,*attribs*)
: An HTML element of name *tag* and list of attributes *attribs*. `($)/2` is defined by the pillow package as an infix, binary operator.

comment(*string*)
: An HTML comment (translates to/from `<!--`*string*`-->`).

declare(*string*)
: An HTML declaration, they are used only in the header (translates to/from `<!`*string*`>`).

string
: Normal text is represented as a list of character codes.

For example, the term

```
env(a,[href="www.therainforestsite.com"],
      ["Visit ",img$[src="TRFS.gif"]])
```

is output to (or parsed from):

```
<a href="www.therainforestsite.com">Visit <img src="TRFS.gif"></a>
```

Usage: `canonic_html_term(HTMLTerm)`

– *Description:* `HTMLTerm` is a term representing HTML code in canonical form.

canonic_xml_term/1: REGTYPE

A term representing XML code in canonical, structured way. It is a list of terms defined by the following predicate (see `tag_attrib/1` definition in `canonic_html_term/1`):

```
canonic_xml_item(Term) :-
        canonic_html_item(Term).
canonic_xml_item(xmldecl(Atts)) :-
        list(Atts,tag_attrib).
canonic_xml_item(env(Tag,Atts,Terms)) :-
        atm(Tag),
        list(Atts,tag_attrib),
        canonic_xml_term(Terms).
canonic_xml_item(elem(Tag,Atts)) :-
        atm(Tag),
        list(Atts,tag_attrib).
```

In addition to the structures defined by `canonic_html_term/1` (the `($)/2` structure appears only in malformed XML code), the following structures can be used:

elem(*tag*,*atts*)
: Specifies an XML empty element of name *tag* and list of attributes *atts*. For example, the term

```
elem(arc,[weigh="3",begin="n1",end="n2"])
```

is output to (or parsed from):

```
<arc weigh="3" begin="n1" end="n2"/>
```

xmldecl(*atts*)
: Specifies an XML declaration with attributes *atts* (translates to/from `<?xml` *atts*`?>`)

Usage: `canonic_xml_term(XMLTerm)`

– *Description:* `XMLTerm` is a term representing XML code in canonical form.

html_term/1: REGTYPE

A term which represents HTML or XML code in a structured way. In addition to the structures defined by `canonic_html_term/1` or `canonic_xml_term/1`, the following structures can be used:

begin(*tag*,*atts*)
: It translates to the start of an HTML environment of name *tag* and attributes *atts*. There exists also a **begin**(*tag*) structure. Useful, in conjunction with the next structure, when including in a document output generated by an existing piece of code (e.g. *tag* = `pre`). Its use is otherwise discouraged.

end(*tag*)
: Translates to the end of an HTML environment of name *tag*.

start
: Used at the beginning of a document (translates to `<html>`).

end
: Used at the end of a document (translates to `</html>`).

`--`
: Produces a horizontal rule (translates to `<hr>`).

`\\`
: Produces a line break (translates to `<br>`).

$
: Produces a paragraph break (translates to `<p>`).

image(*address*)
: Used to include an image of address (URL) *address* (equivalent to `img$[src=`*address*`]`).

image(*address*,*atts*)
: As above with the list of attributes *atts*.

ref(*address*,*text*)
: Produces a hypertext link, *address* is the URL of the referenced resource, *text* is the text of the reference (equivalent to `a([href=`*address*`],`*text*`)`).

label(*name*,*text*)
: Labels *text* as a target destination with label *name* (equivalent to `a([name=`*name*`],`*text*`)`).

heading(*n*,*text*)
: Produces a heading of level *n* (between 1 and 6), *text* is the text to be used as heading. Useful when one wants a heading level relative to another heading (equivalent to `h`*n*`(`*text*`)`).

itemize(*items*)
: Produces a list of bulleted items, *items* is a list of corresponding HTML terms (translates to a `<ul>` environment).

enumerate(*items*)
: Produces a list of numbered items, *items* is a list of corresponding HTML terms (translates to a `<ol>` environment).

description(*defs*)
: Produces a list of defined items, *defs* is a list whose elements are definitions, each of them being a Prolog sequence (composed by `','/2` operators). The last element of the sequence is the definition, the other (if any) are the defined terms (translates to a `<dl>` environment).

nice_itemize(*img*,*items*)
: Produces a list of bulleted items, using the image *img* as bullet. The predicate `icon_address/2` provides a colored bullet.

preformatted(*text*)
: Used to include preformatted text, *text* is a list of HTML terms, each element of the list being a line of the resulting document (translates to a `<pre>` environment).

verbatim(*text*)
: Used to include text verbatim, special HTML characters (`<,>,&,"` and space) are translated into its quoted HTML equivalent.

prolog_term(*term*)
: Includes any prolog term *term*, represented in functional notation. Variables are output as `_`.

nl
: Used to include a newline in the HTML source (just to improve human readability).

entity(*name*)
: Includes the entity of name *name* (ISO-8859-1 special character).

start_form(*addr*,*atts*)
: Specifies the beginning of a form. *addr* is the address (URL) of the program that will handle the form, and *atts* other attributes of the form, as the method used to invoke it. If *atts* is not present (there is only one argument) the method defaults to POST.

start_form
: Specifies the beginning of a form without assigning address to the handler, so that the form handler will be the cgi-bin executable producing the form.

end_form
: Specifies the end of a form.

checkbox(*name*,*state*)
: Specifies an input of type `checkbox` with name *name*, *state* is `on` if the checkbox is initially checked.

radio(*name*,*value*,*selected*)
: Specifies an input of type `radio` with name *name* (several radio buttons which are interlocked must share their name), *value* is the the value returned by the button, if *selected*=*value* the button is initially checked.

input(*type*,*atts*)
: Specifies an input of type *type* with a list of attributes *atts*. Possible values of *type* are `text`, `hidden`, `submit`, `reset`, ldots

textinput(*name*,*atts*,*text*)
: Specifies an input text area of name *name*. *text* provides the default text to be shown in the area, *atts* a list of attributes.

option(*name*,*val*,*options*)
: Specifies a simple option selector of name *name*, *options* is the list of available options and *val* is the initial selected option (if *val* is not in *options* the first item is selected by default) (translates to a `<select>` environment).

menu(*name*,*atts*,*items*)
: Specifies a menu of name *name*, list of attributes *atts* and list of options *items*. The elements of the list *items* are marked with the prefix operator `$` to indicate that they are selected (translates to a `<select>` environment).

form_reply

cgi_reply
: This two are equivalent, they do not generate HTML, rather, the CGI protocol requires this content descriptor to be used at the beginning by CGI executables (including form handlers) when replying (translates to `Content-type: text/html`).

pr Includes in the page a graphical logo with the message "Developed using the PiLLoW Web programming library", which points to the manual and library source.

name(*text*)
A term with functor *name*/1, different from the special functors defined herein, represents an HTML environment of name *name* and included text *text*. For example, the term

```
address('clip@clip.dia.fi.upm.es')
```

is translated into the HTML source

```
<address>clip@clip.dia.fi.upm.es</address>
```

name(*atts*,*text*)
A term with functor *name*/2, different from the special functors defined herein, represents an HTML environment of name *name*, attributes *atts* and included text *text*. For example, the term

```
a([href='http://www.clip.dia.fi.upm.es/'],"Clip home")
```

represents the HTML source

```
<a href="http://www.clip.dia.fi.upm.es/">Clip home</a>
```

Usage: `html_term(HTMLTerm)`
- *Description:* `HTMLTerm` is a term representing HTML code.

form_dict/1: REGTYPE

Usage: `form_dict(Dict)`
- *Description:* `Dict` is a dictionary of values of the attributes of a form. It is a list of `form_assignment`

form_assignment/1: REGTYPE

Usage: `form_assignment(Eq)`
- *Description:* `Eq` is an assignment of value of an attribute of a form. It is defined by:

```
form_assignment(A=V) :-
        atm(A),
        form_value(V).
form_value(A) :-
        atm(A).
form_value(N) :-
        num(N).
form_value(L) :-
        list(L,string).
```

form_value/1: REGTYPE

Usage: `form_value(V)`

– *Description:* `V` is a value of an attribute of a form.

value_dict/1: REGTYPE

Usage: `value_dict(Dict)`

– *Description:* `Dict` is a dictionary of values. It is a list of pairs *atom=constant*.

url_term/1: REGTYPE

A term specifying an Internet Uniform Resource Locator. Currently only HTTP URLs are supported. Example: `http('www.clip.dia.fi.upm.es',80,"/Software/Ciao/")`. Defined as

```
url_term(http(Host,Port,Document)) :-
        atm(Host),
        int(Port),
        string(Document).
```

Usage: `url_term(URL)`

– *Description:* `URL` specifies a URL.

http_request_param/1: REGTYPE

A parameter of an HTTP request:

- **head:** Specify that the document content is not wanted.
- **timeout(***T***):** *T* specifies the time in seconds to wait for the response. Default is 300 seconds.
- **if_modified_since(***Date***):** Get document only if newer than *Date*. *Date* has the format defined by `http_date/1`.
- **user_agent(***Agent***):** Provides a user-agent field, *Agent* is an atom. The string `"PiLLoW/1.1"` (or whatever version of PiLLoW is used) is appended.
- **authorization(***Scheme,Params***):** To provide credentials. See RFC 1945 for details.
- *option*(*Value*): Any unary term, being *Value* an atom, can be used to provide another valid option (e.g. `from('user@machine')`).

Usage: `http_request_param(Request)`

– *Description:* `Request` is a parameter of an HTTP request.

http_response_param/1: REGTYPE

A parameter of an HTTP response:

- **content(***String***):** *String* is the document content (list of bytes). If the `head` parameter of the HTTP request is used, an empty list is get here.
- **status(***Type,Code,Reason***):** *Type* is an atom denoting the response type, *Code* is the status code (an integer), and *Reason* is a string holding the reason phrase.
- **message_date(***Date***):** *Date* is the date of the response, with format defined by `http_date/1`.

- **location**(*Loc*): This parameter appears when the document has moved, *Loc* is an atom holding the new location.
- **http_server**(*Server*): *Server* is the server responding, as a string.
- **authenticate**(*Params*): Returned if document is protected, *Params* is a list of chagenges. See RFC 1945 for details.
- **allow**(*Methods*): *Methods* are the methods allowed by the server, as a list of atoms.
- **content_encoding**(*Encoding*): *Encoding* is an atom defining the encoding.
- **content_length**(*Length*): *Length* is the length of the document (an integer).
- **content_type**(*Type,Subtype,Params*): Specifies the document content type, *Type* and *Subtype* are atoms, *Params* a list of parameters (e.g. `content_type(text,html,[])`).
- **expires**(*Date*): *Date* is the date after which the entity should be considered stale. Format defined by `http_date/1`.
- **last_modified**(*Date*): *Date* is the date at which the sender believes the resource was last modified. Format defined by `http_date/1`.
- **pragma**(*String*): Miscellaneous data.
- *header*(*String*): Any other functor *header*/1 is an extension header.

Usage: `http_response_param(Response)`

— *Description:* `Response` is a parameter of an HTTP response.

http_date/1: REGTYPE

`http_date(Date)`

`Date` is a term defined as

```
http_date(date(WeekDay,Day,Month,Year,Time)) :-
        weekday(WeekDay),
        int(Day),
        month(Month),
        int(Year),
        hms_time(Time).
```

.

Usage: `http_date(Date)`

— *Description:* `Date` is a term denoting a date.

weekday/1: REGTYPE

A regular type, defined as follows:

```
weekday('Monday').
weekday('Tuesday').
weekday('Wednesday').
weekday('Thursday').
weekday('Friday').
weekday('Saturday').
weekday('Sunday').
```

month/1: REGTYPE

A regular type, defined as follows:

```
month('January').
month('February').
month('March').
month('April').
month('May').
month('June').
month('July').
month('August').
month('September').
month('October').
month('November').
month('December').
```

hms_time/1: REGTYPE

Usage: `hms_time(Time)`

– *Description:* `Time` is an atom of the form `hh:mm:ss`

132 Persistent predicate database

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Version of last change: 1.7#96 (2001/5/2, 12:29:31 CEST)

132.1 Introduction to persistent predicates

This library implements a *generic persistent predicate database*. The basic notion implemented by the library is that of a persistent predicate. The persistent predicate concept provides a simple, yet powerful generic persistent data access method [CHGT98,Par97]. A persistent predicate is a special kind of dynamic, data predicate that "resides" in some persistent medium (such as a set of files, a database, etc.) that is typically external to the program using such predicates. The main effect is that any changes made to to a persistent predicate from a program "survive" across executions. I.e., if the program is halted and restarted the predicate that the new process sees is in precisely the same state as it was when the old process was halted (provided no change was made in the meantime to the storage by other processes or the user).

Persistent predicates appear to a program as ordinary predicates, and calls to these predicates can appear in clause bodies in the usual way. However, the definitions of these predicates do not appear in the program. Instead, the library maintains automatically the definitions of predicates which have been declared as persistent in the persistent storage.

Updates to persistent predicates can be made using enhanced versions of `asserta_fact/1`, `assertz_fact/1` and `retract_fact/1`. The library makes sure that each update is a transactional update, in the sense that if the update terminates, then the permanent storage has definitely been modified. For example, if the program making the updates is halted just after the update and then restarted, then the updated state of the predicate will be seen. This provides security against possible data loss due to, for example, a system crash. Also, due to the atomicity of the transactions, persistent predicates allow concurrent updates from several programs.

132.2 Persistent predicates, files, and relational databases

The concept of persistent predicates provided by this library essentially implements a lightweight, simple, and at the same time powerful form of relational database (a deductive database), and which is standalone, in the sense that it does not require external support, other than the file management capabilities provided by the operating system. This is due to the fact that the persistent predicates are in fact stored in one or more auxiliary files below a given directory.

This type of database is specially useful when building small to medium-sized standalone applications in Prolog which require persistent storage. In many cases it provides a much easier way of implementing such storage than using files under direct program control. For example, interactive applications can use persistent predicates to represent their internal state in a way that is close to the application. The persistence of such predicates then allows automatically restoring the state to that at the end of a previous session. Using persistent predicates amounts to simply declaring some predicates as such and eliminates having to worry about opening files, closing them, recovering from system crashes, etc.

In other cases, however, it may be convenient to use a relational database as persistent storage. This may be the case, for example, when the data already resides in such a database (where it is perhaps accessed also by other applications) or the volume of data is very large. `persdb_sql` [CCG98] is a companion library which implements the same notion of persistent

predicates used herein, but keeping the storage in a relational database. This provides a very natural and transparent way to access SQL database relations from a Prolog program. In that library, facilities are also provided for reflecting more complex *views* of the database relations as predicates. Such views can be constructed as conjunctions, disjunctions, projections, etc. of database relations, and may include SQL-like aggregation operations.

A nice characteristic of the notion of persistent predicates used in both of these libraries is that it abstracts away how the predicate is actually stored. Thus, a program can use persistent predicates stored in files or in external relational databases interchangeably, and the type of storage used for a given predicate can be changed without having to modify the program (except for replacing the corresponding `persistent/2` declarations).

An example application of the `persdb` and `persdb_sql` libraries (and also the `pillow` library [CH97]), is `WebDB` [GCH98]. `WebDB` is a generic, highly customizable *deductive database engine* with an *html interface*. `WebDB` allows creating and maintaining Prolog-based databases as well as relational databases (residing in conventional relational database engines) using any standard WWW browser.

132.3 Using file-based persistent predicates

Persistent predicates can be declared statically, using `persistent/2` declarations (which is the preferred method, when possible), or dynamically via calls to `make_persistent/2`. Currently, persistent predicates may only contain facts, i.e., they are *dynamic* predicates of type `data/1`.

Predicates declared as persistent are linked to directory, and the persistent state of the predicate will be kept in several files below that directory. The files in which the persistent predicates are stored are in readable, plain ASCII format, and in Prolog syntax. One advantage of this approach is that such files can also be created or edited by hand, in a text editor, or even by other applications.

An example definition of a persistent predicate implemented by files follows:

```
:- persistent(p/3,dbdir).

persistent_dir(dbdir, '/home/clip/public_html/db').
```

The first line declares the predicate `p/3` persistent. The argument `dbdir` is a key used to index into a fact of the relation `persistent_dir/2`, which specifies the directory where the corresponding files will be kept. The effect of the declaration, together with the `persistent_dir/2` fact, is that, although the predicate is handled in the same way as a normal data predicate, in addition the system will create and maintain efficiently a persistent version of `p/3` via files in the directory `/home/clip/public_html/db`.

The level of indirection provided by the `dbdir` argument makes it easy to place the storage of several persistent predicates in a common directory, by specifying the same key for all of them. It also allows changing the directory for several such persistent predicates by modifying only one fact in the program. Furthermore, the `persistent_dir/2` predicate can even be dynamic and specified at run-time.

132.4 Implementation Issues

We outline the current implementation approach. This implementation attempts to provide at the same time efficiency and security. To this end, up to three files are used for each predicate (the persistence set): the data file, the operations file, and the backup file. In the updated state the facts (tuples) that define the predicate are stored in the data file and the operations file is empty (the backup file, which contains a security copy of the data file, may or may not exist).

While a program using a persistent predicate is running, any insertion (assert) or deletion (retract) operations on the predicate are performed on both the program memory and on the persistence set. However, in order to incurr only a small overhead in the execution, rather than changing the data file directly, a record of each of the insertion and deletion operations is *appended* to the operations file. The predicate is then in a transient state, in that the contents of the data file do not reflect exactly the current state of the corresponding predicate. However, the complete persistence set does.

When a program starts, all pending operations in the operations file are performed on the data file. A backup of the data file is created first to prevent data loss if the system crashes during this operation. The order in which this updating of files is done ensures that, if at any point the process dies, on restart the data will be completely recovered. This process of updating the persistence set can also be triggered at any point in the execution of the program (for example, when halting) by calling `update_files`.

132.5 Defining an initial database

It is possible to define an initial database by simply including in the program code facts of persistent predicates. They will be included in the persistent database when it is created. They are ignored in successive executions.

132.6 Using persistent predicates from the top level

Special care must be taken when loading into the top level modules or user files which use persistent predicates. Beforehand, a goal `use_module(library('persdb/persdbrt'))` must be issued. Furthermore, since persistent predicates defined by the loaded files are in this way defined dynamically, a call to `initialize_db/0` is commonly needed after loading and before calling predicates of these files.

132.7 Usage and interface (`persdbrt`)

- **Library usage:**

  There are two packages which implement persistence: `persdb` and `'persdb/ll'` (for low level). In the first, the standard builtins `asserta_fact/1`, `assertz_fact/1`, and `retract_fact/1` are replaced by new versions which handle persistent data predicates, behaving as usual for normal data predicates. In the second package, predicates with names starting with `p` are defined, so that there is not overhead in calling the standard builtins. In any case, each package is used as usual: including it in the package list of the module, or using the `use_package/1` declaration.
- **Exports:**
  - *Predicates:*

    `passerta_fact/1`, `passertz_fact/1`, `pretract_fact/1`, `asserta_fact/1`, `assertz_fact/1`, `retract_fact/1`, `initialize_db/0`, `make_persistent/2`, `update_files/0`, `update_files/1`.
  - *Multifiles:*

    `persistent_dir/2`.
- **Other modules used:**
  - *System library modules:*

    `terms`, `lists`, `streams`, `read`, `aggregates`, `system`, `file_locks/file_locks`.

132.8 Documentation on exports (persdbrt)

passerta_fact/1: PREDICATE

Meta-predicate with arguments: `passerta_fact(fact)`.

Usage: `passerta_fact(Fact)`

- *Description:* Persistent version of `asserta_fact/1`: the current instance of `Fact` is interpreted as a fact (i.e., a relation tuple) and is added at the beginning of the definition of the corresponding predicate. The predicate concerned must be declared `persistent`. Any uninstantiated variables in the `Fact` will be replaced by new, private variables. Defined in the `'persdb/ll'` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

passertz_fact/1: PREDICATE

Meta-predicate with arguments: `passertz_fact(fact)`.

Usage: `passertz_fact(Fact)`

- *Description:* Persistent version of `assertz_fact/1`: the current instance of `Fact` is interpreted as a fact (i.e., a relation tuple) and is added at the end of the definition of the corresponding predicate. The predicate concerned must be declared `persistent`. Any uninstantiated variables in the `Fact` will be replaced by new, private variables. Defined in the `'persdb/ll'` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

pretract_fact/1: PREDICATE

Meta-predicate with arguments: `pretract_fact(fact)`.

Usage: `pretract_fact(Fact)`

- *Description:* Persistent version of `retract_fact/1`: deletes on backtracking all the facts which unify with `Fact`. The predicate concerned must be declared `persistent`. Defined in the `'persdb/ll'` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

asserta_fact/1: PREDICATE

Meta-predicate with arguments: `asserta_fact(fact)`.

Usage: `asserta_fact(Fact)`

- *Description:* Same as `passerta_fact/1`, but if the predicate concerned is not persistent then behaves as the builtin of the same name. Defined in the `persdb` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

assertz_fact/1: PREDICATE

Meta-predicate with arguments: `assertz_fact(fact)`.

Usage: `assertz_fact(Fact)`

- *Description:* Same as `passertz_fact/1`, but if the predicate concerned is not persistent then behaves as the builtin of the same name. Defined in the `persdb` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

retract_fact/1: PREDICATE

Meta-predicate with arguments: `retract_fact(fact)`.

Usage: `retract_fact(Fact)`

- *Description:* Same as `pretract_fact/1`, but if the predicate concerned is not persistent then behaves as the builtin of the same name. Defined in the `persdb` package.
- *The following properties should hold at call time:*

  `Fact` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

initialize_db/0: PREDICATE

Usage:

- *Description:* Initializes the whole database, updating the state of the declared persistent predicates. Must be called explicitly after dynamically defining clauses for `persistent_dir/2`.

make_persistent/2: PREDICATE

Meta-predicate with arguments: `make_persistent(spec,?)`.

Usage: `make_persistent(PredDesc,Keyword)`

- *Description:* Dynamic version of the `persistent` declaration.
- *The following properties should hold at call time:*

  `PredDesc` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

  (`basic_props:predname/1`)

  `Keyword` is an atom corresponding to a directory identifier. (`persdbrt:keyword/1`)

update_files/0: PREDICATE

Usage:

- *Description:* Updates the files comprising the persistence set of all persistent predicates defined in the application.

update_files/1: PREDICATE

Meta-predicate with arguments: `update_files(list(spec))`.

Usage: `update_files(PredSpecList)`

- *Description:* Updates the files comprising the persistence set of the persistent predicates in `PredSpecList`.
- *Call and exit should be compatible with:*

  `PredSpecList` is a list of `prednames`. (`basic_props:list/2`)

132.9 Documentation on multifiles (persdbrt)

persistent_dir/2: PREDICATE

The predicate is *multifile*.

The predicate is of type *data*.

Usage: `persistent_dir(Keyword,Location_Path)`

- *Description:* Relates identifiers of locations (the `Keywords`) with descriptions of such locations (`Location_Paths`). `Location_Path` is **a directory** and it means that the definition for the persistent predicates associated with `Keyword` is kept in files below that directory (which must previously exist). These files, in the updated state, contain the actual definition of the predicate in Prolog syntax (but with module names resolved).
- *The following properties should hold at call time:*

  `Keyword` is an atom corresponding to a directory identifier. (`persdbrt:keyword/1`)

  `Location_Path` is an atom, the name of a directory. (`persdbrt:directoryname/1`)

132.10 Documentation on internals (persdbrt)

persistent/2: DECLARATION

Usage: `:- persistent(PredDesc,Keyword).`

- *Description:* Declares the predicate `PredDesc` as persistent. `Keyword` is the identifier of a location where the persistent storage for the predicate is kept. The location `Keyword` is described in the `persistent_dir` predicate, which must contain a fact in which the first argument unifies with `Keyword`.
- *The following properties should hold upon exit:*

  `PredDesc` is a Name/Arity structure denoting a predicate name:

```
predname(P/A) :-
        atm(P),
        nnegint(A).
```

  (`basic_props:predname/1`)

  `Keyword` is an atom corresponding to a directory identifier. (`persdbrt:keyword/1`)

keyword/1: REGTYPE

An atom which identifies a fact of the `persistent_dir/2` relation. This fact relates this atom to a directory in which the persistent storage for one or more persistent predicates is kept.

Usage: `keyword(X)`

- *Description:* `X` is an atom corresponding to a directory identifier.

directoryname/1: REGTYPE

Usage: `directoryname(X)`

– *Description:* `X` is an atom, the name of a directory.

132.11 Known bugs and planned improvements (`persdbrt`)

- To load in the toplevel a file which uses this package, module `library('persdb/persdbrt')` has to be previously loaded.

133 Using the persdb library

Through the following examples we will try to illustrate the two mains ways of declaring and using persistent predicates: statically (the preferred method) and dynamically (necessary when the new persistent predicates have to be defined at run-time). The final example is a small application implementing a simple persistent queue.

133.1 An example of persistent predicates (static version)

```
:- use_package(iso).
:- use_package(persdb).

%% Declare the directory associated to the key "db" where the
%% persistence sets of the persistent predicates are stored:
persistent_dir(db,'./').

%% Declare a persistent predicate:
:- persistent(bar/1, db).

%% Read a term, storing it in a new fact of the persistent predicate
%% and list all the current facts of that predicate
main:-
     read(X),
     assertz_fact(bar(X)),
     findall(Y,bar(Y),L),
     write(L).
```

133.2 An example of persistent predicates (dynamic version)

```
:- use_package(iso).
:- use_package(persdb).


main([X]):-
%%   Declare the directory associated to the key "db"
     asserta_fact(persistent_dir(db,'./')),
%%   Declare the predicate bar/1 as dynamic (and data) at run-time
     data(bar/1),
%%   Declare the predicate bar/1 as persistent at run-time
     make_persistent(bar/1, db),
     assertz_fact(bar(X)),
     findall(Y, bar(Y), L),
     write(L).
```

133.3 A simple application / a persistent queue

```
:- module(queue, [main/0],[persdb]).

:- use_package(iso).
```

```
:- use_module(library(read)).
:- use_module(library(write)).
:- use_module(library(aggregates)).

persistent_dir(queue_dir,'./pers').

:- persistent(queue/1, queue_dir).

queue(first).
queue(second).

main:-
     write('Action ( in(Term). | slip(Term) | out. | list. | halt. ): '),
     read(A),
     (  handle_action(A)
     -> true
     ;  write('Unknown command.'), nl ),
     main.

handle_action(end_of_file) :-
     halt.
handle_action(halt) :-
     halt.
handle_action(in(Term)) :-
     assertz_fact(queue(Term)),
     main.
handle_action(slip(Term)) :-
     asserta_fact(queue(Term)),
     main.
handle_action(out) :-
     (  retract_fact(queue(Term))
     -> write('Out '), write(Term)
     ;  write('FIFO empty.') ),
     nl,
     main.
handle_action(list) :-
     findall(Term,queue(Term),Terms),
     write('Contents: '), write(Terms), nl,
     main.
```

134 SQL persistent database interface

Author(s): I. Caballero, D. Cabeza, J.M. Gómez, M. Hermenegildo, J. F. Morales, and M. Carro, clip@dia.fi.upm.es, http://www.clip.dia.fi.upm.es/, The CLIP Group, Facultad de Informática, Universidad Politécnica de Madrid.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#126 (2001/10/26, 14:51:32 CEST)

The purpose of this library is to implement an instance of the generic concept of persistent predicates, where external relational databases are used for storage (see the documentation of the `persdb` library and [CHGT98,Par97] for details). To this end, this library exports SQL persistent versions of the `assertz_fact/1`, `retract_fact/1` and `retractall_fact/1` builtin predicates. Persistent predicates also allow concurrent updates from several programs, since each update is atomic.

The notion of persistence provides a very natural and transparent way to access database relations from a Prolog program. Stub definitions are provided for such predicates which access the database when the predicate is called (using the `db_client` library). A Prolog to SQL translator is used to generate the required SQL code dynamically (see library `pl2sql`).

This library also provides facilities for reflecting more complex views of the database relations as Prolog predicates. Such views can be constructed as conjunctions, disjunctions, projections, etc. of database relations. Also, SQL-like aggregation operations are supported.

134.1 Implementation of the Database Interface

The architecture of the low-level implementation of the database interface was defined with two goals in mind:

- to simplify the communication between the Prolog system and the relational database engines as much as possible, and
- to give as much flexibility as possible to the overall system. This includes simultaneous access to several databases, allowing both the databases and clients to reside on the same physical machine or different machines, and allowing the clients to reside in Win95/NT or Unix machines.

In order to allow the flexibility mentioned above, a client-sever architecture was chosen. At the server side, a MySQL server connects to the databases using the MySQL. At the client side, a MySQL client interface connects to this server. The server daemon (mysqld) should be running in the server machine; check your MySQL documentation on how to do that.

After the connection is established a client can send commands to the mediator server which will pass them to the corresponding database server, and then the data will traverse in the opposite direction. These messages include logging on and off from the database, sending SQL queries, and receiving the responses.

The low level implementation of the current library is accomplished by providing abstraction levels over the MySQL interface library. These layers of abstraction implement the persistent predicate view, build the appropriate commands for the database using a translator of Prolog goals to SQL commands, issue such commands using the mediator send/receive procedures, parse the responses, and present such responses to the Prolog engine via backtracking.

134.2 Example(s)

```
:- module(_, _, [persdb_mysql, functions]).
```

```
:- use_module(library(write)).
:- use_module(library(format)).

:- use_module(user_and_password).

sql_persistent_location(people, db(people, User, Password, HP)):-
        mysql_host_and_port(HP),
        mysql_user(User),
        mysql_password(Password).

:- sql_persistent(
        people(string, string, int),   %% Prolog predicate and types
        people(name, sex, age),        %% Table name and attributes
        people).                       %% Database local id

% Low level MySQL interface.

:- use_module(library('persdb_mysql/mysql_client')).


main :-
        nl,
        display('Creating database'), nl,nl,
        create_people_db,
        nl,
        display('Inserting people'), nl,nl,
        insert_people,
        nl,
        display('Showing people'), nl,nl,
        show_people.

% Create a database and a table of people.  Still needs to be ironed out.

create_people_db :-
        mysql_user(User),
        mysql_password(Password),
        mysql_host_and_port(HP),
        mysql_connect(HP, '', User, Password, DbConnection),

        write(~mysql_query(DbConnection, "drop database if exists people")), nl,
        write(~mysql_query(DbConnection, "create database people")), nl,
        write(~mysql_query(DbConnection, "use people")), nl,
        write(~mysql_query(DbConnection, "create table people(name char(16) not null
        mysql_disconnect(DbConnection).

% Inserts people into the 'people' table.

male(john, 15).
male(peter, 24).
male(ralph, 24).
```

```
male(bart, 50).
female(kirsten, 24).
female(mary, 17).
female(jona, 12).
female(maija, 34).


%% Tuples are inserted as in the local Prolog dynamic database
insert_people :-
        (
            male(N, A),
            display('Inserting '),
            display(male(N, A)),
            nl,
            dbassertz_fact(people(N, male, A)),
            fail
        ;
            true
        ),
        (
            female(N, A),
            display('Inserting '),
            display(female(N, A)),
            nl,
            dbassertz_fact(people(N, female, A)),
            fail
        ;
            true
        ).



 %% Removes people from the 'people' table.

 %% Still not working in MySQL due to differences in SQL: working on it.

remove_people(A, B, C) :-
        dbretractall_fact(people(A, B, C)).

remove_people_2(A, B, C) :-
        dbretract_fact(people(A, B, C)),
        display('Removed row '), display(people(A, B, C)), nl,
        fail.
remove_people_2(_, _, _) :-
         display('No more rows'), nl.


show_people :-
        people(Name, Sex, Age),
        display(people(Name, Sex, Age)),
        nl,
```

```
        fail.
show_people :-
        display('No more rows'), nl.
```

134.3 Usage and interface (persdbrt_mysql)

- **Library usage:**
  Typically, this library is used including the 'persdb_mysql' package into the package list of the module, or using the `use_package/1` declaration:

  In a module:

  ```
  :- module(bar, [main/1], [persdb_mysql]).
  ```

  or

  ```
  :- module(bar, [main/1]).
  :- include(library(persdb_mysql)).
  ```

  In a *user* file:

  ```
  :- use_package([persdb_mysql]).
  ```

  or

  ```
  :- include(library(persdb_mysql)).
  ```

  This loads the run-time and compile-time versions of the library (`persdbtr_mysql.pl` and `persdbrt_mysql.pl`) and includes some needed declarations.
- **Exports:**
  - *Predicates:*

    `init_sql_persdb/0`, `dbassertz_fact/1`, `dbretract_fact/1`, `dbcurrent_fact/1`, `dbretractall_fact/1`, `make_sql_persistent/3`, `dbfindall/4`, `dbcall/2`, `sql_query/3`, `sql_get_tables/2`, `sql_table_types/3`.
  - *Multifiles:*

    `sql_persistent_location/2`.
- **Other modules used:**
  - *System library modules:*

    `det_hook/det_hook_rt`, `persdb_mysql/db_client_types`, `persdb_mysql/pl2sql`, `persdb_sql_common/sqltypes`, `dynamic`, `terms`, `terms_vars`, `messages`, `lists`, `aggregates`, `persdb_mysql/mysql_client`, `persdb_sql_common/pl2sqlinsert`, `persdb_mysql/delete_compiler/pl2sqldelete`.

134.4 Documentation on exports (persdbrt_mysql)

init_sql_persdb/0: PREDICATE

Usage:

- *Description:* Internal predicate, used to transform predicates statically declared as persistent (see `sql_persistent/3`) into real persistent predicates.

dbassertz_fact/1: PREDICATE

Usage: `dbassertz_fact(+Fact)`

- *Description:* Persistent extension of `assertz_fact/1`: the current instance of `Fact` is interpreted as a fact (i.e., a relation tuple) and is added to the end of the definition of the corresponding predicate. If any integrity constraint violation is done (database stored predicates), an error will be displayed. The predicate concerned must be statically (`sql_persistent/3`) or dinamically (`make_sql_persistent/3`) declared. Any uninstantiated variables in the `Fact` will be replaced by new, private variables. **Note:** *assertion of facts with uninstantiated variables not implemented at this time.*
- *Call and exit should be compatible with:*

  `+Fact` is a fact (a term whose main functor is not `':-'/2`). (`persdbrt_mysql:fact/1`)

dbretract_fact/1: PREDICATE

Usage: `dbretract_fact(+Fact)`

- *Description:* Persistent extension of `retract_fact/1`: deletes on backtracking all the facts which unify with `Fact`. The predicate concerned must be statically (`sql_persistent/3`) or dinamically (`make_sql_persistent/3`) declared.
- *Call and exit should be compatible with:*

  `+Fact` is a fact (a term whose main functor is not `':-'/2`). (`persdbrt_mysql:fact/1`)

dbcurrent_fact/1: PREDICATE

Usage: `dbcurrent_fact(+Fact)`

- *Description:* Persistent extension of `current_fact/1`: the fact `Fact` exists in the current database. The predicate concerned must be declared `sql_persistent/3`. Provides on backtracking all the facts (tuples) which unify with `Fact`.
- *Call and exit should be compatible with:*

  `+Fact` is a fact (a term whose main functor is not `':-'/2`). (`persdbrt_mysql:fact/1`)

dbretractall_fact/1: PREDICATE

Usage: `dbretractall_fact(+Fact)`

- *Description:* Persistent extension of `retractall_fact/1`: when called deletes all the facts which unify with `Fact`. The predicate concerned must be statically (`sql_persistent/3`) or dinamically (`make_sql_persistent/3`) declared.
- *Call and exit should be compatible with:*

  `+Fact` is a fact (a term whose main functor is not `':-'/2`). (`persdbrt_mysql:fact/1`)

make_sql_persistent/3: PREDICATE

Meta-predicate with arguments: `make_sql_persistent(addmodule,?,?)`.

Usage: `make_sql_persistent(PrologPredTypes,TableAttributes,Keyword)`

- *Description:* Dynamic version of the `sql_persistent/3` declaration.

– *The following properties should hold upon exit:*

`PrologPredTypes` is a structure describing a Prolog predicate name with its types. (`persdbrt_mysql:prologPredTypes/1`)

`TableAttributes` is a structure describing a table name and some attributes. (`persdbrt_mysql:tableAttributes/1`)

`Keyword` is the name of a persistent storage location. (`persdbrt_mysql:persLocId/1`)

dbfindall/4: PREDICATE

Meta-predicate with arguments: `dbfindall(?,?,goal,?)`.

Usage: `dbfindall(+DBId,+Pattern,+ComplexGoal,-Results)`

– *Description:* Similar to `findall/3`, but `Goal` is executed in database `DBId`. Certain restrictions and extensions apply to both `Pattern` and `ComplexGoal` stemming from the Prolog to SQL translation involved (see the corresponding type definitions for details).

– *Call and exit should be compatible with:*

`+DBId` a unique identifier of a database session connection. (`mysql_client:dbconnection/1`)

`+Pattern` is a database projection term. (`pl2sql:projterm/1`)

`+ComplexGoal` is a database query goal. (`pl2sql:querybody/1`)

`-Results` is a list. (`basic_props:list/1`)

dbcall/2: PREDICATE

Usage: `dbcall(+DBId,+ComplexGoal)`

– *Description:* Internal predicate, used by the transformed versions of the persistent predicates. Not meant to be called directly by users. It is exported by the library so that it can be used by the transformed versions of the persistent predicates in the modules in which they reside. Sends `ComplexGoal` to database `DBId` for evaluation. `ComplexGoal` must be a call to a persistent predicate which resides in database `DBId`.

– *Call and exit should be compatible with:*

`+DBId` a unique identifier of a database session connection. (`mysql_client:dbconnection/1`)

`+ComplexGoal` is a database query goal. (`pl2sql:querybody/1`)

sql_query/3: PREDICATE

Usage: `sql_query(+DBId,+SQLString,AnswerTableTerm)`

– *Description:* `ResultTerm` is the response from database `DBId` to the SQL query in `SQLString` to database `DBId`. `AnswerTableTerm` can express a set of tuples, an error answer or a 'ok' response (see `answertableterm/1` for details). At the moment, `sql_query/3` log in and out for each query. This should be changed to log in only the first time and log out on exit and/or via a timer in the standard way.

– *Call and exit should be compatible with:*

`+DBId` a unique identifier of a database session connection. (`mysql_client:dbconnection/1`)

`+SQLString` is a string containing SQL code. (`pl2sql:sqlstring/1`)

`AnswerTableTerm` is a response from the ODBC database interface. (`persdbrt_mysql:answertableterm/1`)

sql_get_tables/2: PREDICATE

Usage 1: `sql_get_tables(+Location,-Tables)`

- *Description:* `Tables` contains the tables available in `Location`.
- *Call and exit should be compatible with:*

  `persdbrt_mysql:persLocation(+Location)` (`persdbrt_mysql:persLocation/1`)

  `-Tables` is a list of `atms`. (`basic_props:list/2`)

Usage 2: `sql_get_tables(+DbConnection,-Tables)`

- *Description:* `Tables` contains the tables available in `DbConnection`.
- *Call and exit should be compatible with:*

  `+DbConnection` a unique identifier of a database session connection. (`mysql_client:dbconnection/1`)

  `-Tables` is a list of `atms`. (`basic_props:list/2`)

sql_table_types/3: PREDICATE

Usage 1: `sql_table_types(+Location,+Table,-AttrTypes)`

- *Description:* `AttrTypes` are the attributes and types of `Table` in `Location`.
- *Call and exit should be compatible with:*

  `persdbrt_mysql:persLocation(+Location)` (`persdbrt_mysql:persLocation/1`)

  `+Table` is an atom. (`basic_props:atm/1`)

  `-AttrTypes` is a list. (`basic_props:list/1`)

Usage 2: `sql_table_types(+DbConnection,+Table,-AttrTypes)`

- *Description:* `AttrTypes` are the attributes and types of `Table` in `DbConnection`.
- *Call and exit should be compatible with:*

  `+DbConnection` a unique identifier of a database session connection. (`mysql_client:dbconnection/1`)

  `+Table` is an atom. (`basic_props:atm/1`)

  `-AttrTypes` is a list. (`basic_props:list/1`)

socketname/1: REGTYPE

Usage: `socketname(IPP)`

- *Description:* `IPP` is a structure describing a complete TCP/IP port address.

dbname/1: REGTYPE

Usage: `dbname(DBId)`

- *Description:* `DBId` is the identifier of an database.

user/1: REGTYPE

Usage: `user(User)`

- *Description:* `User` is a user name in the database.

passwd/1: REGTYPE

Usage: `passwd(Passwd)`

– *Description:* `Passwd` is the password for the user name in the database.

projterm/1: REGTYPE

Usage: `projterm(DBProjTerm)`

– *Description:* `DBProjTerm` is a database projection term.

querybody/1: REGTYPE

Usage: `querybody(DBGoal)`

– *Description:* `DBGoal` is a database query goal.

sqltype/1: (UNDOC_REEXPORT)

Imported from `sqltypes` (see the corresponding documentation for details).

134.5 Documentation on multifiles (`persdbrt_mysql`)

sql_persistent_location/2: PREDICATE

Relates names of locations (the `Keywords`) with descriptions of such locations (`Locations`).

The predicate is *multifile*.

The predicate is of type *data*.

Usage 1: `sql_persistent_location(Keyword,Location)`

– *Description:* `Keyword` is an identifier for the persistent data location `Location`.

– *Call and exit should be compatible with:*

`Keyword` is the name of a persistent storage location. (`persdbrt_mysql:persLocId/1`)

`persdbrt_mysql:persLocation(Location)` (`persdbrt_mysql:persLocation/1`)

Usage 2: `sql_persistent_location(Keyword,DBLocation)`

– *Description:* In this usage, `DBLocation` is a *relational database*, in which case the predicate is stored as tuples in the database.

– *The following properties should hold upon exit:*

`Keyword` is the name of a persistent storage location. (`persdbrt_mysql:persLocId/1`)

`DBLocation` is a structure describing a database. (`persdbrt_mysql:database_desc/1`)

134.6 Documentation on internals (persdbrt_mysql)

sql_persistent/3: DECLARATION

Usage: :- sql_persistent(PrologPredTypes,TableAttributes,Keyword).

– *Description:* Declares the predicate corresponding to the main functor of PrologPredTypes as SQL persistent. Keyword is the name of a location where the persistent storage for the predicate is kept, which in this case must be an external relational database. The description of this database is given through the sql_persistent_location predicate, which must contain a fact in which the first argument unifies with Keyword. TableAttributes provides the table name and attributes in the database corresponding respectively to the predicate name and arguments of the (virtual) Prolog predicate.

Example:

```
:- sql_persistent(product( integer,    integer, string, string ),
                  product( quantity,   id,      name,   size   ),
                  radiowebdb).

sql_persistent_location(radiowebdb,
   db('SQL Anywhere 5.0 Sample', user, pass,
      'r2d5.dia.fi.upm.es':2020)).
```

– *The following properties should hold upon exit:*

PrologPredTypes is a structure describing a Prolog predicate name with its types. (persdbrt_mysql:prologPredTypes/1)

TableAttributes is a structure describing a table name and some attributes. (persdbrt_mysql:tableAttributes/1)

Keyword is the name of a persistent storage location. (persdbrt_mysql:persLocId/1)

db_query/4: PREDICATE

Usage: db_query(+DBId,+ProjTerm,+Goal,ResultTerm)

– *Description:* ResultTerm contains all the tuples which are the response from database DBId to the Prolog query Goal, projected onto ProjTerm. Uses pl2sqlstring/3 for the Prolog to SQL translation and sql_query/3 for posing the actual query.

– *Call and exit should be compatible with:*

+DBId a unique identifier of a database session connection. (mysql_client:dbconnection/1)

+ProjTerm is a database projection term. (pl2sql:projterm/1)

+Goal is a database query goal. (pl2sql:querybody/1)

ResultTerm is a tuple of values from the ODBC database interface. (persdbrt_mysql:tuple/1)

db_query_one_tuple/4: PREDICATE

Usage: db_query_one_tuple(+DBId,+ProjTerm,+Goal,ResultTerm)

– *Description:* ResultTerm is one of the tuples which are the response from database DBId to the Prolog query Goal, projected onto ProjTerm. Uses pl2sqlstring/3 for the Prolog to SQL translation and sql_query_one_tuple/3 for posing the actual

query. After last tuple has been reached, a null tuple is unified with ResultTerm, and the connection to the database finishes.

– *Call and exit should be compatible with:*

`+DBId` a unique identifier of a database session connection. (`mysql_client:dbconnection/1`)

`+ProjTerm` is a database projection term. (`pl2sql:projterm/1`)

`+Goal` is a database query goal. (`pl2sql:querybody/1`)

`ResultTerm` is a predicate containing a tuple. (`persdbrt_mysql:answertupleterm/1`)

sql_query_one_tuple/3: PREDICATE

Usage: `sql_query_one_tuple(+DBId,+SQLString,ResultTuple)`

– *Description:* `ResultTuple` contains an element from the set of tuples which represents the response in `DBId` to the SQL query `SQLString`. If the connection is kept, succesive calls return consecutive tuples, until the last tuple is reached. Then a null tuple is unified with `ResultTuple` and the connection is finished (calls to `mysql_disconnect/1`).

– *Call and exit should be compatible with:*

`+DBId` a unique identifier of a database session connection. (`mysql_client:dbconnection/1`)

`+SQLString` is a string containing SQL code. (`pl2sql:sqlstring/1`)

`ResultTuple` is a tuple of values from the ODBC database interface. (`persdbrt_mysql:tuple/1`)

dbconnection/1: REGTYPE

Usage: `dbconnection(H)`

– *Description:* `H` a unique identifier of a database session connection.

tuple/1: REGTYPE

```
tuple(T) :-
        list(T,atm).
tuple(T) :-
        list(T,atm).
```

Usage: `tuple(T)`

– *Description:* `T` is a tuple of values from the ODBC database interface.

134.7 Known bugs and planned improvements (`persdbrt_mysql`)

- At least in the shell, reloading a file after changing the definition of a persistent predicate does not eliminate the old definition...
- Functionality missing: some questions need to be debugged.
- Warning: still using kludgey string2term and still using some non-uniquified temp files.
- Needs to be unified with the file-based library.

135 Prolog to SQL translator

Author(s): C. Draxler. Adapted by M. Hermenegildo and I. Caballero.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 0.9#96 (1999/5/21, 19:53:48 MEST)

This library performs translation of Prolog queries into SQL. The code is an adaptation for Ciao of the Prolog to SQL compiler written by Christoph Draxler, CIS Centre for Information and Speech Processing, Ludwig-Maximilians-University Munich, `draxler@cis.uni-muenchen.de`, Version 1.1. Many thanks to Christoph for allowing us to include this adaptation of his code with Ciao.

The translator needs to know the correspondence between Prolog predicates and the SQL tables in the database. To this end this module exports two multifile predicates, `relation/3` and `attribute/4`. See the description of these predicates for details on how such correspondance is specified.

The main entry points to the translator are `pl2sqlstring/3` and `pl2sqlterm/3`. Details on the types of queries allowed can be found in the description of these predicates.

Example: the following program would print out a term representing the SQL query corresponding to the given Prolog query:

```
:- use_module(library('persdb_sql/pl2sql')).
:- use_module(library(strings)).

:- multifile [relation/3,attribute/4].
:- data [relation/3,attribute/4].

relation(product,3,'PRODUCT').
attribute(1,'PRODUCT','ID',int).
attribute(2,'PRODUCT','QUANTITY',int).
attribute(3,'PRODUCT','NAME',string).

main :-
     pl2sqlstring( f(L,K),
          ((product(L,N,a); product(L,N,b)),
           \+ product(2,3,b),
           L + 2 > avg(Y, Z^product(Z,Y,a)),
           K is N + max(X, product(X,2,b))
           ), T),
     write_string(T).

%%     printqueries(T).
```

Note: while the translator can be used directly in programs, it is more convenient to use a higher-level abstraction: persistent predicates (implemented in the `persdb` library). The notion of persistent predicates provides a completely transparent interface between Prolog and relational databases. When using this library, the Prolog to SQL translation is called automatically as needed.

135.1 Usage and interface (pl2sql)

- **Library usage:**
  `:- use_module(library(pl2sql)).`
- **Exports:**
  - *Predicates:*
    `pl2sqlstring/3`, `pl2sqlterm/3`, `sqlterm2string/2`.
  - *Regular Types:*
    `querybody/1`, `projterm/1`, `sqlstring/1`.
  - *Multifiles:*
    `relation/3`, `attribute/4`.
- **Other modules used:**
  - *System library modules:*
    `persdb_sql_common/sqltypes`, `iso_misc`, `lists`, `aggregates`, `messages`.

135.2 Documentation on exports (pl2sql)

pl2sqlstring/3: PREDICATE

Usage: `pl2sqlstring(+ProjectionTerm,+DatabaseGoal,-SQLQueryString)`

- *Description:* This is the top level predicate which translates complex Prolog goals into the corresponding SQL code.

  The query code is prepared in such a way that the result is projected onto the term `ProjectionTerm` (also in a similar way to the first argument of `setof/3`)). See the predicate `translate_projection/3` for restrictions on this term.

  `SQLQueryString` contains the code of the SQL query, ready to be sent to an SQL server.
- *Call and exit should be compatible with:*

  `+ProjectionTerm` is a database projection term. (`pl2sql:projterm/1`)

  `+DatabaseGoal` is a database query goal. (`pl2sql:querybody/1`)

  `-SQLQueryString` is a string containing SQL code. (`pl2sql:sqlstring/1`)

querybody/1: REGTYPE

`DBGoal` is a goal meant to be executed in the external database. It can be a complex term containing conjunctions, disjunctions, and negations, of:

- Atomic goals, which must have been defined via `relation/3` and `attribute/4` and reside in the (same) database. Their arguments must be either ground or free variables. If they are ground, they must be bound to constants of the type declared for that argument. If an argument is a free variable, it may *share* with (i.e., be the same variable as) other free variables in other goal arguments.
- Database comparison goals, whose main functor must be a database comparison operator (see `pl2sql: comparison/2`) and whose arguments must be *database arithmetic expressions.*

- Database calls to is/2. The left side of such a call may be either unbound, in which case it is bound to the result of evaluating the right side, or bound in which case an equality condition is tested. The right side must be a *database arithmetic expression.*

The binding of variables follows Prolog rules:

- variables are bound by positive base goals and on the left side of the `is/2` predicate.
- Comparison operations, negated goals, and right sides of the `is/2` predicate do not return variable bindings and may even require all arguments to be bound for a safe evaluation.

Database arithmetic expressions may contain:

- Numeric constants (i.e., integers, reals, etc.).
- Bound variables, i.e., variables which will be bound during execution through occurrence within a positive database goal, or by a preceding arithmetic function.
- Database arithmetic functions, which are a subset of those typically accepted within `is/2` (see `pl2sql`: `arithmetic_functor/2`).
- Database aggregation functions, each of which has two arguments: a variable indicating the argument over which the function is to be computed, and a goal argument which must contain in at least one argument position the variable (e.g. `avg(Seats, plane(Type, Seats))`). The goal argument may only be a conjunction of (positive or negative) base goals. See `pl2sql`: `aggregate_functor/2` for the admissible aggregate functions.

In addition, variables can be existentially quantified using `^/2` (in a similar way to how it is done in `setof/3`).

Note that it is assumed that the arithmetic operators in Prolog and SQL are the same, i.e., `+` is addition in Prolog and in SQL, etc.

Usage: `querybody(DBGoal)`

– *Description:* `DBGoal` is a database query goal.

projterm/1: REGTYPE

`DBProjTerm` is a term onto which the result of a database query code is (in a similar way to the first argument of `setof/3`)).

A `ProjectionTerm` must meet the following restrictions:

- The functor of `ProjectionTerm` may not be one of the built-in predicates, i.e. ',', ';', etc. are not allowed.
- Only variables and constants are allowed as arguments, i.e., no structured terms may appear.

Usage: `projterm(DBProjTerm)`

– *Description:* `DBProjTerm` is a database projection term.

sqlstring/1: REGTYPE

```
sqlstring(S) :-
        string(S).
```

Usage: `sqlstring(S)`

– *Description:* `S` is a string containing SQL code.

pl2sqlterm/3: PREDICATE

Usage: `pl2sqlterm(+ProjectionTerm,+DatabaseGoal,-SQLQueryTerm)`

- *Description:* Similar to `pl2sqlstring/3` except that `SQLQueryTerm` is a representation of the SQL query as a Prolog term.
- *Call and exit should be compatible with:*

  `+ProjectionTerm` is a database projection term. (`pl2sql:projterm/1`)

  `+DatabaseGoal` is a database query goal. (`pl2sql:querybody/1`)

  `-SQLQueryTerm` is a list of `sqlterms`. (`basic_props:list/2`)

sqlterm2string/2: PREDICATE

Usage: `sqlterm2string(+Queries,-QueryString)`

- *Description:* `QueryString` is a string representation of the list of queries in Prolog-term format in `Queries`.
- *Call and exit should be compatible with:*

  `+Queries` is a list of `sqlterms`. (`basic_props:list/2`)

  `-QueryString` is a string containing SQL code. (`pl2sql:sqlstring/1`)

sqltype/1: (UNDOC_REEXPORT)

Imported from `sqltypes` (see the corresponding documentation for details).

135.3 Documentation on multifiles (`pl2sql`)

relation/3: PREDICATE

The predicate is *multifile*.

The predicate is of type *data*.

Usage: `relation(PredName,Arity,TableName)`

- *Description:* This predicate, together with `attribute/4`, defines the correspondence between Prolog predicates and the SQL tables in the database. These two relations constitute an extensible meta-database which maps Prolog predicate names to SQL table names, and Prolog predicate argument positions to SQL attributes.

  `PredName` is the chosen Prolog name for an SQL table. `Arity` is the number of arguments of the predicate. `TableName` is the name of the SQL table in the Database Management System.
- *Call and exit should be compatible with:*

  `PredName` is an atom. (`basic_props:atm/1`)

  `Arity` is an integer. (`basic_props:int/1`)

  `TableName` is an atom. (`basic_props:atm/1`)

attribute/4: PREDICATE

The predicate is *multifile*.

The predicate is of type *data*.

Usage: `attribute(ANumber,TblName,AName,AType)`

– *Description:* This predicate maps the argument positions of a Prolog predicate to the SQL attributes of its corresponding table. The types of the arguments need to be specified, and this information is used for consistency checking during the translation and for output formatting. A minimal type system is provided to this end. The allowable types are given by `sqltype/1`.

`ANumber` is the argument number in the Prolog relation. `TblName` is the name of the SQL table in the Database Management System. `AName` is the name of the corresponding attribute in the table. `AType` is the (translator) data type of the attribute.

– *Call and exit should be compatible with:*

`ANumber` is an integer.	(`basic_props:int/1`)
`TblName` is an atom.	(`basic_props:atm/1`)
`AName` is an atom.	(`basic_props:atm/1`)
`AType` is an SQL data type supported by the translator.	(`sqltypes:sqltype/1`)

135.4 Documentation on internals (`pl2sql`)

query_generation/3: PREDICATE

Usage:
`query_generation(+ListOfConjunctions,+ProjectionTerm,-ListOfQueries)`

– *Description:* For each Conjunction in `ListOfConjunctions`, translate the pair `(ProjectionTerm, Conjunction)` to an SQL query and connect each such query through a UNION-operator to result in the `ListOfQueries`.

A Conjunction consists of positive or negative subgoals. Each subgoal is translated as follows:

- the functor of a goal that is not a comparison operation is translated to a relation name with a range variable,
- negated goals are translated to NOT EXISTS-subqueries with * projection,
- comparison operations are translated to comparison operations in the WHERE-clause,
- aggregate function terms are translated to aggregate function (sub)queries.

The arguments of a goal are translated as follows:

- `variables of a goal` are translated to qualified attributes,
- variables occurring in several goals are translated to equality comparisons (equi join) in the WHERE-clause,
- constant arguments are translated to equality comparisons in the WHERE-clause.

Arithmetic functions are treated specially (`translate_arithmetic_function/5`). See also `querybody/1` for details on the syntax accepted and restrictions.

translate_conjunction/5: PREDICATE

Usage: `translate_conjunction(Conjunction,SQLFrom,SQLWhere,Dict,NewDict)`

– *Description:* Translates a conjunction of goals (represented as a list of goals preceeded by existentially quantified variables) to FROM-clauses and WHERE-clauses of an SQL query. A dictionary containing the associated SQL table and attribute names is built up as an accumulator pair (arguments `Dict` and `NewDict`).

translate_goal/5: PREDICATE

Usage: `translate_goal(Goal,SQLFrom,SQLWhere,Dict,NewDict)`

– *Description:* Translates:

- a positive database goal to the associated FROM- and WHERE clause of an SQL query,
- a negated database goal to a negated existential subquery,
- an arithmetic goal to an arithmetic expression or an aggregate function query,
- a comparison goal to a comparison expression, and
- a negated comparison goal to a comparison expression with the opposite comparison operator.

translate_arithmetic_function/5: PREDICATE

Usage:
`translate_arithmetic_function(Result,Expression,SQLWhere,Dict,NewDict)`

– *Description:* Arithmetic functions (left side of is/2 operator is bound to value of expression on right side) may be called with either:

- `Result` unbound: then `Result` is bound to the value of the evaluation of `Expression`,
- `Result` bound: then an equality condition is returned between the value of `Result` and the value of the evaluation of `Expression`.

  Only the equality test shows up in the WHERE clause of an SQLquery.

translate_comparison/5: PREDICATE

Usage: `translate_comparison(LeftArg,RightArg,CompOp,Dict,SQLComparison)`

– *Description:* Translates the left and right arguments of a comparison term into the appropriate comparison operation in SQL. The result type of each argument expression is checked for type compatibility.

aggregate_function/3: PREDICATE

Usage:
`aggregate_function(AggregateFunctionTerm,Dict,AggregateFunctionQuery)`

– *Description:* Supports the Prolog aggregate function terms listed in `aggregate_functor/2` within arithmetic expressions. Aggregate functions are translated to the corresponding SQL built-in aggregate functions.

comparison/2: PREDICATE

Usage: `comparison(PrologOperator,SQLOperator)`

– *Description:* Defines the mapping between Prolog operators and SQL operators:

```
comparison(=,=).
comparison(<,<).
comparison(>,>).
comparison(@<,<).
comparison(@>,>).
```

– *Call and exit should be compatible with:*

`PrologOperator` is an atom. (`basic_props:atm/1`)

`SQLOperator` is an atom. (`basic_props:atm/1`)

negated_comparison/2: PREDICATE

Usage: `negated_comparison(PrologOperator,SQLOperator)`

– *Description:* Defines the mapping between Prolog operators and the complementary SQL operators:

```
negated_comparison(=,<>).
negated_comparison(\==,=).
negated_comparison(>,=<).
negated_comparison(=<,>).
negated_comparison(<,>=).
negated_comparison(>=,<).
```

– *Call and exit should be compatible with:*

`PrologOperator` is an atom. (`basic_props:atm/1`)

`SQLOperator` is an atom. (`basic_props:atm/1`)

arithmetic_functor/2: PREDICATE

Usage: `arithmetic_functor(PrologFunctor,SQLFunction)`

– *Description:* Defines the admissible arithmetic functions on the Prolog side and their correspondence on the SQL side:

```
arithmetic_functor(+,+).
arithmetic_functor(-,-).
arithmetic_functor(*,*).
arithmetic_functor(/,/).
```

– *Call and exit should be compatible with:*

`PrologFunctor` is an atom. (`basic_props:atm/1`)

`SQLFunction` is an atom. (`basic_props:atm/1`)

aggregate_functor/2: PREDICATE

Usage: `aggregate_functor(PrologFunctor,SQLFunction)`

– *Description:* Defines the admissible aggregate functions on the Prolog side and their correspondence on the SQL side:

```
aggregate_functor(avg,'AVG').
aggregate_functor(min,'MIN').
aggregate_functor(max,'MAX').
aggregate_functor(sum,'SUM').
aggregate_functor(count,'COUNT').
```

– *Call and exit should be compatible with:*

`PrologFunctor` is an atom. (`basic_props:atm/1`)

`SQLFunction` is an atom. (`basic_props:atm/1`)

135.5 Known bugs and planned improvements (`pl2sql`)

- Need to separate db predicate names by module.

136 Low-level socket interface to SQL/ODBC databases

Author(s): Jose Morales.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#209 (2002/4/24, 14:50:46 CEST)

This library provides a low-level interface to MySQL using the MySQL C API and the Ciao foreign interface to C.

136.1 Usage and interface (`mysql_client`)

- **Library usage:**

  `:- use_module(library(mysql_client)).`
- **Exports:**
  - *Predicates:*

    `mysql_connect/5`, `mysql_query/3`, `mysql_query_one_tuple/3`, `mysql_free_query_connection/1`, `mysql_fetch/2`, `mysql_get_tables/2`, `mysql_table_types/3`, `mysql_disconnect/1`.
  - *Regular Types:*

    `dbconnection/1`, `dbqueryconnection/1`.
- **Other modules used:**
  - *System library modules:*

    `foreign_interface/foreign_interface_properties`, `persdb_mysql/db_client_types`.

136.2 Documentation on exports (`mysql_client`)

mysql_connect/5: PREDICATE

No further documentation available for this predicate.

dbconnection/1: REGTYPE

```
dbconnection(_1) :-
        address(_1).
```

Usage: `dbconnection(H)`

- *Description:* `H` a unique identifier of a database session connection.

mysql_query/3: PREDICATE

No further documentation available for this predicate.

mysql_query_one_tuple/3: PREDICATE

No further documentation available for this predicate.

dbqueryconnection/1: REGTYPE

```
dbqueryconnection(_1) :-
        address(_1).
```

Usage: `dbqueryconnection(H)`

– *Description:* `H` is a unique identifier of a query answer in a database session connection.

mysql_free_query_connection/1: PREDICATE

No further documentation available for this predicate.

mysql_fetch/2: PREDICATE

No further documentation available for this predicate.

mysql_get_tables/2: PREDICATE

No further documentation available for this predicate.

mysql_table_types/3: PREDICATE

No further documentation available for this predicate.

mysql_disconnect/1: PREDICATE

No further documentation available for this predicate.

137 Types for the Low-level interface to SQL databases

Author(s): D. Cabeza, M. Carro, I. Caballero, and M. Hermenegildo..

137.1 Usage and interface (db_client_types)

- **Library usage:**
  `:- use_module(library(db_client_types)).`
- **Exports:**
  - *Regular Types:*
    `socketname/1`, `dbname/1`, `user/1`, `passwd/1`, `answertableterm/1`, `tuple/1`, `answertupleterm/1`, `sqlstring/1`.

137.2 Documentation on exports (db_client_types)

socketname/1: REGTYPE

```
socketname(IPAddress:PortNumber) :-
        atm(IPAddress),
        int(PortNumber).
```

Usage: `socketname(IPP)`

- *Description:* `IPP` is a structure describing a complete TCP/IP port address.

dbname/1: REGTYPE

```
dbname(DBId) :-
        atm(DBId).
```

Usage: `dbname(DBId)`

- *Description:* `DBId` is the identifier of an database.

user/1: REGTYPE

```
user(User) :-
        atm(User).
```

Usage: `user(User)`

- *Description:* `User` is a user name in the database.

passwd/1: REGTYPE

```
passwd(Passwd) :-
        atm(Passwd).
```

Usage: `passwd(Passwd)`

- *Description:* `Passwd` is the password for the user name in the database.

answertableterm/1: REGTYPE

Represents the types of responses that will be returned from the database interface. These can be a set of answer tuples, or the atom `ok` in case of a successful addition or deletion.

Usage: `answertableterm(AT)`

– *Description:* `AT` is a response from the database interface.

tuple/1: REGTYPE

```
tuple(T) :-
        list(T,atm).
```

Usage: `tuple(T)`

– *Description:* `T` is a tuple of values from the database interface.

answertupleterm/1: REGTYPE

```
answertupleterm([]).
answertupleterm(tup(T)) :-
        tuple(T).
```

Usage: `answertupleterm(X)`

– *Description:* `X` is a predicate containing a tuple.

sqlstring/1: REGTYPE

```
sqlstring(S) :-
        string(S).
```

Usage: `sqlstring(S)`

– *Description:* `S` is a string of SQL code.

138 sqltypes (library)

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#127 (2001/10/26, 14:52:5 CEST)

138.1 Usage and interface (sqltypes)

- **Library usage:**
  `:- use_module(library(sqltypes)).`
- **Exports:**
  - *Predicates:*
    `accepted_type/2`, `get_type/2`, `type_compatible/2`, `type_union/3`, `sybase2sqltypes_list/2`, `sybase2sqltype/2`, `postgres2sqltypes_list/2`, `postgres2sqltype/2`.
  - *Regular Types:*
    `sqltype/1`, `sybasetype/1`, `postgrestype/1`.

138.2 Documentation on exports (sqltypes)

sqltype/1: REGTYPE

```
sqltype(int).
sqltype(flt).
sqltype(num).
sqltype(string).
sqltype(date).
sqltype(time).
sqltype(datetime).
```

These types have the same meaning as the corresponding standard types in the `basictypes` library.

Usage: `sqltype(Type)`

- *Description:* `Type` is an SQL data type supported by the translator.

accepted_type/2: PREDICATE

Usage: `accepted_type(SystemType,NativeType)`

- *Description:* For the moment, tests wether the `SystemType` received is a sybase or a postgres type (in the future other systems should be supported) and obtains its equivalent `NativeType` sqltype.
- *Call and exit should be compatible with:*
  `SystemType` is an SQL data type supported by Sybase. (`sqltypes:sybasetype/1`)
  `NativeType` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

get_type/2: PREDICATE

Usage: `get_type(+Constant,Type)`

- *Description:* Prolog implementation-specific definition of type retrievals. CIAO Prolog version given here (ISO).
- *Call and exit should be compatible with:*

  `+Constant` is any term. (`basic_props:term/1`)

  `Type` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

type_compatible/2: PREDICATE

Usage: `type_compatible(TypeA,TypeB)`

- *Description:* Checks if `TypeA` and `TypeB` are compatible types, i.e., they are the same or one is a subtype of the other.
- *Call and exit should be compatible with:*

  `TypeA` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

  `TypeB` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

type_union/3: PREDICATE

Usage: `type_union(TypeA,TypeB,Union)`

- *Description:* `Union` is the union type of `TypeA` and `TypeB`.
- *Call and exit should be compatible with:*

  `TypeA` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

  `TypeB` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

  `Union` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

sybasetype/1: REGTYPE

SQL datatypes supported by Sybase for which a translation is defined:

```
sybasetype(integer).
sybasetype(numeric).
sybasetype(float).
sybasetype(double).
sybasetype(date).
sybasetype(char).
sybasetype(varchar).
sybasetype('long varchar').
sybasetype(binary).
sybasetype('long binary').
sybasetype(timestamp).
sybasetype(time).
sybasetype(tinyint).
```

Usage: `sybasetype(Type)`

- *Description:* `Type` is an SQL data type supported by Sybase.

sybase2sqltypes_list/2: PREDICATE

Usage: `sybase2sqltypes_list(SybaseTypesList,SQLTypesList)`

- *Description:* `SybaseTypesList` is a list of Sybase SQL types. `PrologTypesList` contains their equivalent SQL-type names in CIAO.
- *The following properties should hold upon exit:*

  `SybaseTypesList` is a list. (`basic_props:list/1`)

  `SQLTypesList` is a list. (`basic_props:list/1`)

sybase2sqltype/2: PREDICATE

Usage: `sybase2sqltype(SybaseType,SQLType)`

- *Description:* `SybaseType` is a Sybase SQL type name, and `SQLType` is its equivalent SQL-type name in CIAO.
- *The following properties should hold upon exit:*

  `SybaseType` is an SQL data type supported by Sybase. (`sqltypes:sybasetype/1`)

  `SQLType` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

postgrestype/1: REGTYPE

SQL datatypes supported by postgreSQL for which a translation is defined:

```
postgrestype(int2).
postgrestype(int4).
postgrestype(int8).
postgrestype(float4).
postgrestype(float8).
postgrestype(date).
postgrestype(timestamp).
postgrestype(time).
postgrestype(char).
postgrestype(varchar).
postgrestype(text).
postgrestype(bool).
```

Usage: `postgrestype(Type)`

- *Description:* `Type` is an SQL data type supported by postgres.

postgres2sqltypes_list/2: PREDICATE

Usage: `postgres2sqltypes_list(PostgresTypesList,SQLTypesList)`

- *Description:* `PostgresTypesList` is a list of postgres SQL types. `PrologTypesList` contains their equivalent SQL-type names in CIAO.
- *The following properties should hold upon exit:*

  `PostgresTypesList` is a list. (`basic_props:list/1`)

  `SQLTypesList` is a list. (`basic_props:list/1`)

postgres2sqltype/2: PREDICATE

Usage: `postgres2sqltype(PostgresType,SQLType)`

- *Description:* `PostgresType` is a postgres SQL type name, and `SQLType` is its equivalent SQL-type name in CIAO.
- *The following properties should hold upon exit:*

  `PostgresType` is an SQL data type supported by postgres. (`sqltypes:postgrestype/1`)

  `SQLType` is an SQL data type supported by the translator. (`sqltypes:sqltype/1`)

139 persdbtr_sql (library)

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 0.7#17 (1998/10/1, 10:29:56 MET DST)

139.1 Usage and interface (persdbtr_sql)

- **Library usage:**
  `:- use_module(library(persdbtr_sql)).`
- **Exports:**
  - *Predicates:*
    `sql_persistent_tr/2`.

139.2 Documentation on exports (persdbtr_sql)

sql_persistent_tr/2: PREDICATE

No further documentation available for this predicate.

140 pl2sqlinsert (library)

Version: 0.1 (1998/7/9, 18:10:22 MET DST)

140.1 Usage and interface (pl2sqlinsert)

- **Library usage:**
  `:- use_module(library(pl2sqlinsert)).`
- **Exports:**
  - *Predicates:*
    `pl2sqlInsert/2`.
  - *Multifiles:*
    `relation/3`, `attribute/4`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`.

140.2 Documentation on exports (pl2sqlinsert)

pl2sqlInsert/2: PREDICATE

No further documentation available for this predicate.

140.3 Documentation on multifiles (pl2sqlinsert)

relation/3: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

attribute/4: PREDICATE

No further documentation available for this predicate.

The predicate is *multifile*.

The predicate is of type *data*.

141 Low-level Prolog to Java interface

Author(s): Jesús Correas.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#74 (2001/3/26, 12:12:29 CEST)

This module defines the low level Prolog to Java interface. This interface allows a Prolog program to start a Java process, create Java objects, invoke methods, set/get attributes (fields), and handle Java events.

This interface only works with JDK version 1.2 or higher.

Although the Java side interface is explained in Javadoc format (it is available at library/javall/javadoc/ in your Ciao installation), the general interface structure is detailed here.

141.1 Low-Level Prolog to Java Interface Structure

This low-level prolog to java interface is made up of two parts: a Prolog part and a Java part, running in separate processes. The Prolog part receives requests from a Prolog program and sends them to the Java part through a socket. The Java part receives requests from the socket and performs the actions included in the requests.

If an event is thrown in the java side, an asynchronous message must be sent away to the prolog side, in order to launch a prolog goal to handle the event. This asynchronous communication is made by the means of a second socket. The nature of this communication needs the use of threads both in java and prolog: to deal with the 'sequential program flow,' and other threads for event handling.

In both sides the threads are automatically created by the context of the objects we use. The user must be aware that different requests to the other side of the interface could run concurrently.

141.1.1 Prolog side of the Java interface

The prolog side receives the actions to do in the java side from the user program, and sends them to the java side through the socket connection. When the action is done in the java side, the result is returned to the user program, or the action fails if there is any problem in the java side.

Prolog data representation of java elements is very simple in this low-level interface. Java primitive types such as integers and characters are translated into Prolog terms, and even some Java objects are translated that way (e. g. Java strings). Java objects are represented in Prolog as compound terms with a reference to identify the corresponding Java object. Data conversion is made automatically when the interface is used, so the Prolog user programs do not have to deal with the complexity of this tasks.

141.1.2 Java side

The java side of this layer is more complex than the prolog side. The tasks this part have to deal to are the following:

- Wait for requests from the prolog side.
- Translate the prolog terms received in a 'serialized' form in a more useful java representation.
- Interpret the requests received from the prolog side.
- Handle the set of objects created by or derived from the requests received from de prolog side.
- Handle the events raised in the java side, and launch the listeners added in the prolog side.

- Handle the exceptions raised in the java side, and send to the prolog side.

In the implementation of the java side, two items must be carefully designed: the handling of java objects, and the representation of prolog data structures. The last item is specially important because all the interactions between prolog and java are made using prolog structures, an easy way to standardize the different data management of both languages. Even the requests themselves are encapsulated using prolog structures. The overload of this encapsulation is not significant in terms of socket traffic, due to the optimal implementation of the prolog serialized term.

The java side must handle the objects created from the prolog side dinamically, and these objects must be accessed as fast as possible from the set of objects. The java API provides a powerful implementation of Hash tables that achieves all the requirements of our implementation.

On the other hand, the java representation of prolog terms is made using the inheritance of java classes. In the java side exists a representation of a generic prolog term, implemented as an abstract class in java. Variables, atoms, compound terms, lists, and numeric terms are classes in the java side which inherit from the term class. Java objects can be seen also under the prolog representation as compound terms, where the single argument corresponds to the Hash key of the actual java object in the Hash table referred to before. This behaviour makes the handling of mixed java and prolog elements easy. Prolog goals are represented in the java side as objects which contain a prolog compound term with the term representing the goal. This case will be seen more in depth next, when the java to prolog is explained.

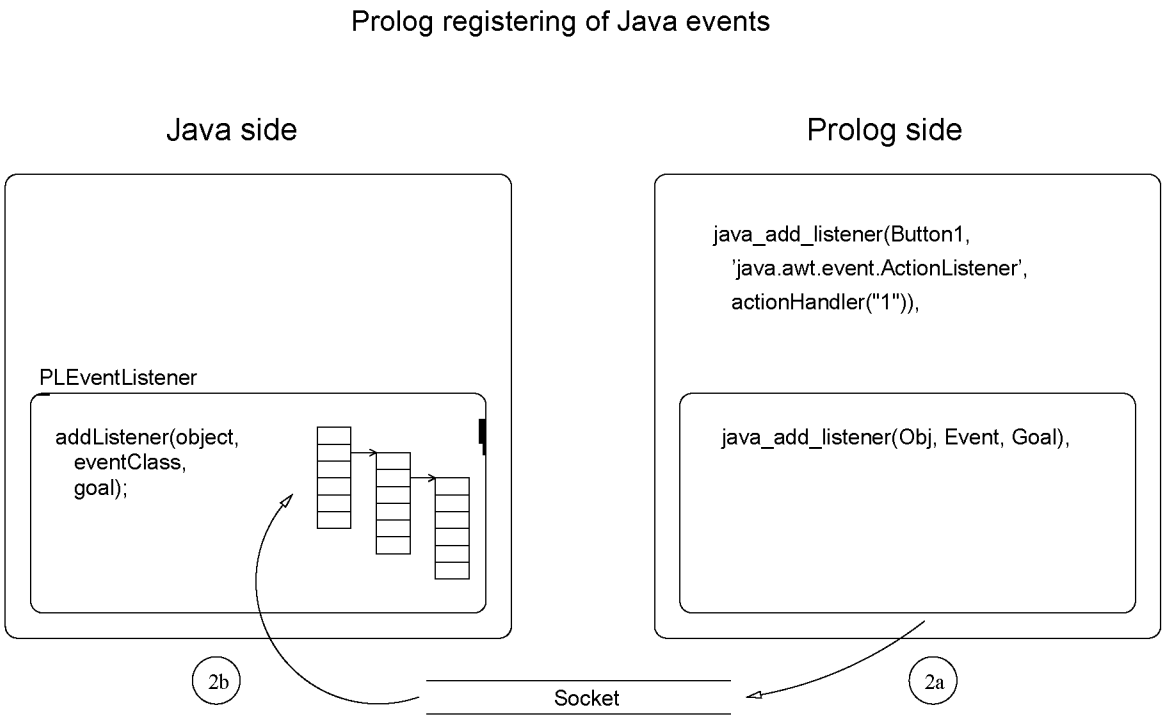
141.2 Java event handling from Prolog

Java event handling is based on a delegation model since version 1.1.x. This approach to event handling is very powerful and elegant, but a user program cannot handle all the events that can arise on a given object: for each kind of event, a listener must be implemented and added specifically. However, the Java 2 API includes a special listener (`AWTEventListener`) that can manage the internal java event queue.

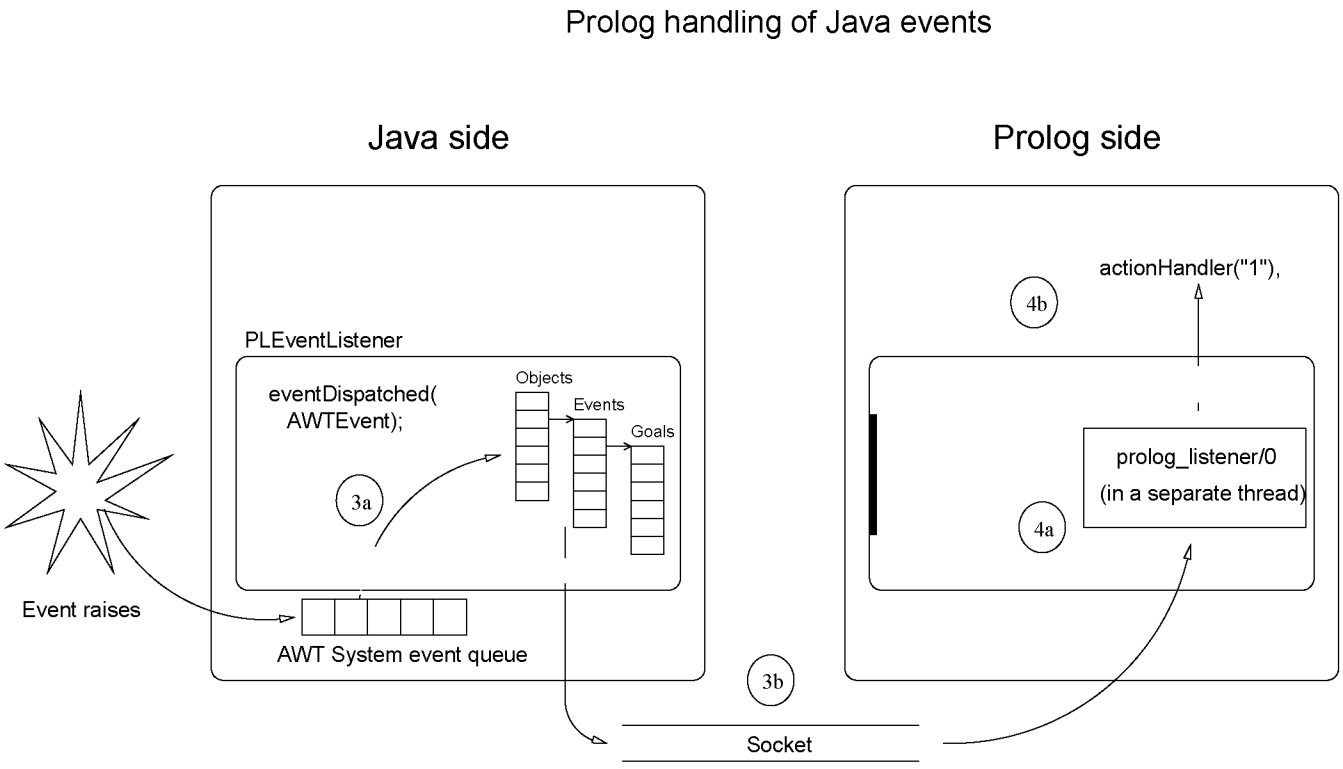
The prolog to java interface has been designed to emulate the java event handler, and is also based on event objects and listeners. The low level prolog to java interface implements its own event manager, to handle those events that have prolog listeners associated to the object that raises the event. From the prolog side can be added listeners to objects for specific events. The java side includes a list of goals to launch from the object and event type.

Due to the events nature, the event handler must work in a separate thread to manage the events asynchronously. The java side has its own mechanisms to work this way. The prolog side must be implemented specially for event handling using threads. The communication between java and prolog is also asynchronous, and an additional socket stream is used to avoid interferences with the main socket stream. The event stream will work in this implementation only in one way: from java to prolog. If an event handler needs to send back requests to java, it will use the main socket stream, just like the requests sent directly from a prolog program.

The internal process of register a Prolog event handler to a Java event is shown in the next figure:



When an event raises, the low-level Prolog to Java interface has to send to the Prolog user program the goal to evaluate. Graphically, the complete process takes the tasks involved in the following figure:



141.3 Java exception handling from Prolog

Java exception handling is very similar to the peer prolog handling: it includes some specific statements to trap exceptions from user code. In the java side, the exceptions can be originated from an incorrect request, or can be originated in the code called from the request. Both exception types will be sent to prolog using the main socket stream, allowing the prolog program manage the exception. However, the first kind of exceptions are prefixed, so the user program can distinguish them from the second type of exceptions.

In order to handle exceptions properly using the prolog to java and java to prolog interfaces simultaneously, in both sides of the interface will be filtered those exceptions coming from their own side: this avoids an endless loop of exceptions bouncing from one side to another.

141.4 Usage and interface (javart)

- **Library usage:**
  `:- use_module(library(javart)).`
- **Exports:**
  - *Predicates:*
    `java_start/0`, `java_start/1`, `java_start/2`, `java_stop/0`, `java_connect/2`, `java_disconnect/0`, `java_use_module/1`, `java_create_object/2`, `java_delete_object/1`, `java_invoke_method/2`, `java_get_value/2`, `java_set_value/2`, `java_add_listener/3`, `java_remove_listener/3`.
  - *Regular Types:*
    `machine_name/1`, `java_constructor/1`, `java_object/1`, `java_event/1`, `prolog_goal/1`, `java_field/1`, `java_method/1`.
- **Other modules used:**
  - *System library modules:*
    `concurrency/concurrency`, `iso_byte_char`, `format`, `lists`, `read`, `write`, `javall/javasock`, `system`.

141.5 Documentation on exports (javart)

java_start/0: PREDICATE

No further documentation available for this predicate.

java_start/1: PREDICATE

Usage: `java_start(+classpath)`

- *Description:* Starts the Java server on the local machine, connects to it, and starts the event handling thread. The Java server is started using the classpath received as argument.
- *Call and exit should be compatible with:*
  `+classpath` is a string (a list of character codes). (`basic_props:string/1`)

java_start/2: PREDICATE

Usage: `java_start(+machine_name,+classpath)`

- *Description:* Starts the Java server in machine_name (using rsh!), connects to it, and starts the event handling thread. The Java server is started using the classpath received as argument.
- *Call and exit should be compatible with:*

  `+machine_name` is currently instantiated to an atom. (`term_typing:atom/1`)

  `+classpath` is a string (a list of character codes). (`basic_props:string/1`)

java_stop/0: PREDICATE

Usage:

- *Description:* Stops the interface terminating the threads that handle the socket connection, and finishing the Java interface server if it was started using java_start/n.

java_connect/2: PREDICATE

Usage: `java_connect(+machine_name,+port_number)`

- *Description:* Connects to an existing Java interface server running in machine_name and listening at port port_number. To connect to a Java server located in the local machine, use 'localhost' as machine_name.
- *Call and exit should be compatible with:*

  `+machine_name` is the network name of a machine. (`javart:machine_name/1`)

  `+port_number` is an integer. (`basic_props:int/1`)

java_disconnect/0: PREDICATE

Usage:

- *Description:* Closes the connection with the java process, terminating the threads that handle the connection to Java. This predicate does not terminate the Java process (this is the disconnection procedure for Java servers not started from Prolog). This predicate should be used when the communication is established with java_connect/2.

machine_name/1: REGTYPE

Usage: `machine_name(X)`

- *Description:* `X` is the network name of a machine.

java_constructor/1: REGTYPE

Usage: `java_constructor(X)`

- *Description:* `X` is a java constructor (structure with functor as constructor full name, and arguments as constructor arguments).

java_object/1: REGTYPE

Usage: `java_object(X)`

- *Description:* `X` is a java object (a structure with functor '$java_object', and argument an integer given by the java side).

java_event/1: REGTYPE

Usage: `java_event(X)`

- *Description:* `X` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener').

prolog_goal/1: REGTYPE

Usage: `prolog_goal(X)`

- *Description:* `X` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called.

java_field/1: REGTYPE

Usage: `java_field(X)`

- *Description:* `X` is a java field (structure on which the functor name is the field name, and the single argument is the field value).

java_use_module/1: PREDICATE

No further documentation available for this predicate.

java_create_object/2: PREDICATE

Usage: `java_create_object(+java_constructor,-java_object)`

- *Description:* New java object creation. The constructor must be a compound term as defined by its type, with the full class name as functor (e.g., 'java.lang.String'), and the parameters passed to the constructor as arguments of the structure.
- *Call and exit should be compatible with:*

  `+java_constructor` is a java constructor (structure with functor as constructor full name, and arguments as constructor arguments). (`javart:java_constructor/1`)

  `-java_object` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (`javart:java_object/1`)

java_delete_object/1: PREDICATE

Usage: `java_delete_object(+java_object)`

- *Description:* Java object deletion. It removes the object given as argument from the Java object table.

– *Call and exit should be compatible with:*

`+java_object` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (`javart:java_object/1`)

java_invoke_method/2: PREDICATE

Usage: `java_invoke_method(+java_object,+java_method)`

– *Description:* Invokes a java method on an object. Given a Java object reference, invokes the method represented with the second argument.

– *Call and exit should be compatible with:*

`+java_object` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (`javart:java_object/1`)

`+java_method` is a java method (structure with functor as method name, and arguments as method ones, plus a result argument. This result argument is unified with the atom 'Yes' if the java method returns void). (`javart:java_method/1`)

java_method/1: REGTYPE

Usage: `java_method(X)`

– *Description:* `X` is a java method (structure with functor as method name, and arguments as method ones, plus a result argument. This result argument is unified with the atom 'Yes' if the java method returns void).

java_get_value/2: PREDICATE

Usage: `java_get_value(+java_object,+java_field)`

– *Description:* Gets the value of a field. Given a Java object as first argument, it instantiates the variable given as second argument. This field must be uninstantiated in the java_field functor, or this predicate will fail.

– *Call and exit should be compatible with:*

`+java_object` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (`javart:java_object/1`)

`+java_field` is a java field (structure on which the functor name is the field name, and the single argument is the field value). (`javart:java_field/1`)

java_set_value/2: PREDICATE

Usage: `java_set_value(+java_object,+java_field)`

– *Description:* Sets the value of a Java object field. Given a Java object reference, it assigns the value included in the java_field compound term. The field value in the java_field structure must be instantiated.

– *Call and exit should be compatible with:*

`+java_object` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (`javart:java_object/1`)

`+java_field` is a java field (structure on which the functor name is the field name, and the single argument is the field value). (`javart:java_field/1`)

java_add_listener/3: PREDICATE

Meta-predicate with arguments: `java_add_listener(?,?,goal)`.

Usage: `java_add_listener(+java_object,+java_event,+prolog_goal)`

- *Description:* Adds a listener to an event on an object. Given a Java object reference, it registers the goal received as third argument to be launched when the Java event raises.
- *Call and exit should be compatible with:*

  `+java_object` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (`javart:java_object/1`)

  `+java_event` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener'). (`javart:java_event/1`)

  `+prolog_goal` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called. (`javart:prolog_goal/1`)

java_remove_listener/3: PREDICATE

Usage: `java_remove_listener(+java_object,+java_event,+prolog_goal)`

- *Description:* It removes a listener from an object event queue. Given a Java object reference, goal registered for the given event is removed.
- *Call and exit should be compatible with:*

  `+java_object` is a java object (a structure with functor '$java_object', and argument an integer given by the java side). (`javart:java_object/1`)

  `+java_event` is a java event represented as an atom with the full event constructor name (e.g., 'java.awt.event.ActionListener'). (`javart:java_event/1`)

  `+prolog_goal` is a prolog predicate. Prolog term that represents the goal that must be invoked when the event raises on the object. The predicate arguments can be java objects, or even the result of java methods. These java objects will be evaluated when the event raises (instead of when the listener is added). The arguments that represent java objects must be instantiated to already created objects. The variables will be kept uninstantiated when the event raises and the predicate is called. (`javart:prolog_goal/1`)

142 Low-level Java to Prolog interface

Author(s): Jesús Correas.

Version: 1.8#2 (2002/6/14, 18:55:4 CEST)

Version of last change: 1.7#125 (2001/10/17, 13:42:47 CEST)

This module defines a low level Java to Prolog interface. This Prolog side of the Java to Prolog interface only has one public predicate: a server that listens at the socket connection with Java, and executes the commands received from the Java side.

In order to evaluate the goals received from the Java side, this module can work in two ways: executing them in the same engine, or starting a thread for each goal. The easiest way is to launch them in the same engine, but the goals must be evaluated sequentially: once a goal provides the first solution, all the subsequent goals must be finished before this goal can backtrack to provide another solution. The Prolog side of this interface works as a top-level, and the goals partially evaluated are not independent.

The solution of this goal dependence is to evaluate the goals in a different prolog engine. Although Ciao includes a mechanism to evaluate goals in different engines, the approach used in this interface is to launch each goal in a different thread.

The decision of what kind of goal evaluation is selected is done by the Java side. Each evaluation type has its own command terms, so the Java side can choose the type it needs.

A Prolog server starts by calling the `prolog_server/0` predicate, or by calling `prolog_server/1` predicate and providing the port number as argument. The user predicates and libraries to be called from Java must be included in the executable file, or be accesible using the built-in predicates dealing with code loading.

142.1 Usage and interface (`jtopl`)

- **Library usage:**

  `:- use_module(library(jtopl)).`
- **Exports:**
  - *Predicates:*

    `prolog_server/0`, `prolog_server/1`, `shell_s/0`, `query_solutions/2`, `query_requests/2`, `running_queries/2`.
- **Other modules used:**
  - *System library modules:*

    `concurrency/concurrency`, `system`, `read`, `write`, `dynamic`, `lists`, `format`, `compiler/compiler`, `atom2term`, `javall/javasock`, `prolog_sys`.

142.2 Documentation on exports (`jtopl`)

prolog_server/0: PREDICATE

Usage:

- *Description:* Prolog server entry point. Reads from the standard input the node name and port number where the java client resides, and starts the prolog server listening at the jp socket. This predicate acts as a server: it includes an endless read-process loop until the `prolog_halt` command is received.

prolog_server/1: PREDICATE

Usage:

- *Description:* Prolog server entry point. Given a port number, starts the prolog server listening at the jp socket. This predicate acts as a server: it includes an endless read-process loop until the `prolog_halt` command is received.
- *Call and exit should be compatible with:*

  `Arg1` is an atom. (`basic_props:atm/1`)

shell_s/0: PREDICATE

Usage:

- *Description:* Command execution loop. This predicate is called when the connection to Java is established, and performs an endless loop processing the commands received.

query_solutions/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *concurrent*.

query_requests/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *concurrent*.

running_queries/2: PREDICATE

No further documentation available for this predicate.

The predicate is of type *concurrent*.

142.3 Documentation on internals (`jtopl`)

command/1: REGTYPE

Usage: `command(X)`

- *Description:* `X` is a command received from the java client, to be executed by the Prolog process. The command is represented as an atom or a functor with arity 1. The command to be executed must be one of the following types:
  - `prolog_launch_query(Q)` Compound term to create a new query, received as single argument of this structure. A reference to the new query is returned to Java.
  - `prolog_next_solution` Atom to get the next solution of a goal. A term representing the goal instantiated with the next solution is returned to Java.
  - `prolog_execute` Atom to indicate that next solution of a goal must be got, without blocking the requester (it has to check if this goal is still running using prolog_is_running command).
  - `prolog_terminate_query` Atom to indicate that a goal must be terminated.

- `prolog_use_module(M)` Compound term to load dynamically a module given as argument.
- `prolog_is_running` Atom to check if a goal is yet running a prolog_execute command.
- `prolog_halt` Atom to terminate the current Prolog process.

answer/1: REGTYPE

Usage: `answer(X)`

– *Description:* `X` is a response sent from the prolog server. Is represented as an atom or a functor with arity 1 or 2, depending on the functor name.

process_command/1: PREDICATE

No further documentation available for this predicate.

solve/2: PREDICATE

Usage: `solve(+Query,+JId)`

– *Description:* Runs the query on a separate thread and stores the solutions on the `query_solutions/2` data predicate.

– *Call and exit should be compatible with:*

`+Query` is a term which represents a goal, i.e., an atom or a structure. (`basic_props:callable/1`)

`+JId` is any term. (`basic_props:term/1`)

prolog_parse/2: PREDICATE

Usage: `prolog_parse(+String,-Term)`

– *Description:* Parses the string received as first argument and returns the prolog term as second argument. **Important:** This is a private predicate but could be called from java side, to parse strings to Prolog terms.

– *Call and exit should be compatible with:*

`+String` is a string (a list of character codes). (`basic_props:string/1`)

`-Term` is any term. (`basic_props:term/1`)

read_command/1: PREDICATE

No further documentation available for this predicate.

write_answer/2: PREDICATE

Usage: `write_answer(+Id,+Answer)`

– *Description:* writes to the output socket stream the given answer.

– *Call and exit should be compatible with:*

`+Id` is a prolog query identifier. (`jtopl:prolog_query_id/1`)

`+Answer` is a response sent from the prolog server. Is represented as an atom or a functor with arity 1 or 2, depending on the functor name.

(`jtopl:answer/1`)

143 Low-level Prolog to Java socket connection

Author(s): Jesús Correas.

Version: 1.8#2 (2002/6/14, 18:55:4 CEST)

This module defines a low level socket interface, to be used by javart and jtopl. Includes all the code related directly to the handling of sockets. This library should not be used by any user program, because is a very low-level connection to Java. Use `javart` (Prolog to Java low-level interface) or `jtopl` (Java to Prolog interface) libraries instead.

143.1 Usage and interface (javasock)

- **Library usage:**
  `:- use_module(library(javasock)).`
- **Exports:**
  - *Predicates:*
    `start_socket_interface/2`, `stop_socket_interface/0`, `join_socket_interface/0`, `java_query/2`, `java_response/2`, `prolog_query/2`, `prolog_response/2`, `java_stream/4`, `java_debug/1`.
- **Other modules used:**
  - *System library modules:*
    `fastrw`, `read`, `sockets/sockets`, `dynamic`, `format`, `concurrency/concurrency`, `javall/jtopl`.

143.2 Documentation on exports (javasock)

start_socket_interface/2: PREDICATE

Usage: `start_socket_interface(+Address,+Stream)`

- *Description:* Given an address in format 'node:port', creates the sockets to connect to the java process, and starts the threads needed to handle the connection.
- *Call and exit should be compatible with:*
  `+Address` is any term. (`basic_props:term/1`)
  `+Stream` is an open stream. (`streams_basic:stream/1`)

stop_socket_interface/0: PREDICATE

Usage:

- *Description:* Closes the sockets to disconnect from the java process, and waits until the threads that handle the connection terminate.

join_socket_interface/0: PREDICATE

Usage:

- *Description:* Waits until the threads that handle the connection terminate.

java_query/2: PREDICATE

The predicate is of type *concurrent.*

Usage: `java_query(ThreadId,Query)`

– *Description:* Data predicate containing the queries to be sent to Java. First argument is the Prolog thread Id, and second argument is the query to send to Java.

– *Call and exit should be compatible with:*

`ThreadId` is an atom. (`basic_props:atm/1`)

`Query` is any term. (`basic_props:term/1`)

java_response/2: PREDICATE

The predicate is of type *concurrent.*

Usage: `java_response(Id,Response)`

– *Description:* Data predicate that stores the responses to requests received from Java. First argument corresponds to the Prolog thread Id; second argument corresponds to the response itself.

– *Call and exit should be compatible with:*

`Id` is an atom. (`basic_props:atm/1`)

`Response` is any term. (`basic_props:term/1`)

prolog_query/2: PREDICATE

The predicate is of type *concurrent.*

Usage: `prolog_query(Id,Query)`

– *Description:* Data predicate that keeps a queue of the queries requested to Prolog side from Java side.

– *Call and exit should be compatible with:*

`Id` is an integer. (`basic_props:int/1`)

`Query` is any term. (`basic_props:term/1`)

prolog_response/2: PREDICATE

The predicate is of type *concurrent.*

Usage: `prolog_response(Id,Response)`

– *Description:* Data predicate that keeps a queue of the responses to queries requested to Prolog side from Java side.

– *Call and exit should be compatible with:*

`Id` is an integer. (`basic_props:int/1`)

`Response` is any term. (`basic_props:term/1`)

java_stream/4: PREDICATE

The predicate is of type *data.*

Usage: `java_stream(PJStream,JPStream,Address,Stream)`

– *Description:* Stores the identifiers of the streams used. A fact is asserted when the connection to the Java process is established. It Contains prolog-to-java and java-to-prolog streams, and the network address where the Java process is running. Last argument represents the Java process standard input stream.
– *Call and exit should be compatible with:*

`PJStream` is a compound term.	(`basic_props:struct/1`)
`JPStream` is a compound term.	(`basic_props:struct/1`)
`Address` is a valid host name.	(`javasock:machine_name/1`)
`Stream` is an open stream.	(`streams_basic:stream/1`)

java_debug/1: PREDICATE

No further documentation available for this predicate.

144 Calling emacs from Prolog

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#54 (2000/2/10, 21:32:23 CET)

This library provides a *prolog-emacs interface*. This interface is complementary to (and independent from) the emacs mode, which is used to develop programs from within the `emacs` editor/environment. Instead, this library allows calling `emacs` from a running Prolog program. This facilitates the use of `emacs` as a "user interface" for a Prolog program. Emacs can be made to:

- Visit a file, which can then be edited.
- Execute arbitrary *emacs lisp* code, sent from Prolog.

In order for this library to work correctly, the following is needed:

- You should be running the `emacs` editor on the same machine where the executable calling this library is executing.
- This `emacs` should be running the *emacs server*. This can be done by including the following line in your `.emacs` file:

```
;; Start a server that emacsclient can connect to.
(server-start)
```

  Or typing `M-x server-start` within `emacs`.

This suffices for using `emacs` to edit files. For running arbitrary code the following also needs to be added to the `.emacs` file:

`(setq enable-local-eval t)`
: Allows executing lisp code without asking.

`(setq enable-local-eval nil)`
: Does not allow executing lisp code without asking.

`(setq enable-local-eval 'maybe)`
: Allows executing lisp code only if user agrees after asking (asks interactively for every invocation).

Examples:

Assuming that a `.pl` file loads this library, then:

`..., emacs_edit('foo'), ...`
: Opens file `foo` for editing in `emacs`.

`..., emacs_eval_nowait("(run-ciao-toplevel)"), ...`
: Starts execution of a Ciao top-level within `emacs`.

144.1 Usage and interface (emacs)

- **Library usage:**
  `:- use_module(library(emacs)).`
- **Exports:**
  - *Predicates:*
    `emacs_edit/1`, `emacs_edit_nowait/1`, `emacs_eval/1`, `emacs_eval_nowait/1`.
  - *Regular Types:*
    `elisp_string/1`.
- **Other modules used:**
  - *System library modules:*
    `terms_check`, `lists`, `terms`, `system`.

144.2 Documentation on exports (emacs)

emacs_edit/1: PREDICATE

Usage: `emacs_edit(+filename)`

- *Description:* Opens the given file for editing in `emacs`. Waits for editing to finish before continuing.

emacs_edit_nowait/1: PREDICATE

Usage: `emacs_edit_nowait(+filename)`

- *Description:* Opens the given file for editing in `emacs` and continues without waiting for editing to finish.

emacs_eval/1: PREDICATE

Usage: `emacs_eval(+elisp_string)`

- *Description:* Executes in emacs the lisp code given as argument. Waits for the command to finish before continuing.

emacs_eval_nowait/1: PREDICATE

Usage: `emacs_eval_nowait(+elisp_string)`

- *Description:* Executes in emacs the lisp code given as argument and continues without waiting for it to finish.

elisp_string/1: REGTYPE

Usage: `elisp_string(L)`

- *Description:* `L` is a string containing `emacs` lisp code.

145 linda (library)

Version: 0.9#66 (1999/4/29, 12:28:0 MEST)

This is a SICStus-like linda package. Note that this is essentially quite obsolete, and provided mostly in case it is needed for compatibility, since Ciao now supports all Linda functionality (and more) through the concurrent fact database.

145.1 Usage and interface (`linda`)

- **Library usage:**

  `:- use_module(library(linda)).`
- **Exports:**
  - *Predicates:*

    `linda_client/1`, `close_client/0`, `in/1`, `in/2`, `in_noblock/1`, `out/1`, `rd/1`, `rd/2`, `rd_noblock/1`, `rd_findall/3`, `linda_timeout/2`, `halt_server/0`, `open_client/2`, `in_stream/2`, `out_stream/2`.
- **Other modules used:**
  - *System library modules:*

    `read`, `fastrw`, `sockets/sockets`.

145.2 Documentation on exports (`linda`)

linda_client/1: PREDICATE

No further documentation available for this predicate.

close_client/0: PREDICATE

No further documentation available for this predicate.

in/1: PREDICATE

No further documentation available for this predicate.

in/2: PREDICATE

No further documentation available for this predicate.

in_noblock/1: PREDICATE

No further documentation available for this predicate.

out/1: PREDICATE

No further documentation available for this predicate.

rd/1: PREDICATE

No further documentation available for this predicate.

rd/2: PREDICATE

No further documentation available for this predicate.

rd_noblock/1: PREDICATE

No further documentation available for this predicate.

rd_findall/3: PREDICATE

No further documentation available for this predicate.

linda_timeout/2: PREDICATE

No further documentation available for this predicate.

halt_server/0: PREDICATE

No further documentation available for this predicate.

open_client/2: PREDICATE

No further documentation available for this predicate.

in_stream/2: PREDICATE

No further documentation available for this predicate.

out_stream/2: PREDICATE

No further documentation available for this predicate.

PART IX - Abstract data types

This part includes libraries which implement some generic data structures (abstract data types) that are used frequently in programs or in the Ciao system itself.

146 counters (library)

Version: 0.4#5 (1998/2/24)

146.1 Usage and interface (counters)

- **Library usage:**
  `:- use_module(library(counters)).`
- **Exports:**
  - *Predicates:*
    `setcounter/2`, `getcounter/2`, `inccounter/2`.

146.2 Documentation on exports (counters)

setcounter/2: PREDICATE

No further documentation available for this predicate.

getcounter/2: PREDICATE

No further documentation available for this predicate.

inccounter/2: PREDICATE

No further documentation available for this predicate.

147 Identity lists

Author(s): Francisco Bueno.

Version: 0.4#5 (1998/2/24)

The operations in this module handle lists by performing equality checks via identity instead of unification.

147.1 Usage and interface (idlists)

- **Library usage:**

  `:- use_module(library(idlists)).`
- **Exports:**
  - *Predicates:*

    `member_0/2`, `memberchk/2`, `list_insert/2`, `add_after/4`, `add_before/4`, `delete/3`, `subtract/3`, `union_idlists/3`.

147.2 Documentation on exports (idlists)

member_0/2: PREDICATE

No further documentation available for this predicate.

memberchk/2: PREDICATE

`memberchk(X,Xs)`

Checks that `X` is an element of (list) `Xs`.

list_insert/2: PREDICATE

Usage: `list_insert(-List,+Term)`

- *Description:* Adds `Term` to the end of (tail-opened) `List` if there is not an element in `List` identical to `Term`.

add_after/4: PREDICATE

Usage: `add_after(+L0,+E0,+E,-L)`

- *Description:* Adds element `E` after the first element identical to `E0` (or at end) of list `L0`, returning in `L` the new list.

add_before/4: PREDICATE

Usage: `add_before(+L0,+E0,+E,-L)`

- *Description:* Adds element `E` before the first element identical to `E0` (or at start) of list `L0`, returning in `L` the new list.

delete/3: PREDICATE

Usage: `delete(+List,+Element,-Rest)`

– *Description:* `Rest` has the same elements of `List` except for all the occurrences of elements identical to `Element`.

subtract/3: PREDICATE

Usage: `subtract(+Set,+Set0,-Difference)`

– *Description:* `Difference` has the same elements of `Set` except those which have an identical occurrence in `Set0`.

union_idlists/3: PREDICATE

Usage: `union_idlists(+List1,+List2,-List)`

– *Description:* `List` has the elements which are in `List1` but are not identical to an element in `List2` followed by the elements in `List2`.

148 Lists of numbers

Version: 0.9#99 (1999/5/26, 11:33:15 MEST)

148.1 Usage and interface (numlists)

- **Library usage:**
  `:- use_module(library(numlists)).`
- **Exports:**
  - *Predicates:*
    `get_primes/2`, `sum_list/2`, `sum_list/3`, `sum_list_of_lists/2`, `sum_list_of_lists/3`.
  - *Regular Types:*
    `intlist/1`, `numlist/1`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

148.2 Documentation on exports (numlists)

get_primes/2: PREDICATE

Usage: `get_primes(N,Primes)`

- *Description:* Computes the `N`th first prime numbers in ascending order.
- *The following properties should hold at call time:*
  `N` is an integer. (`basic_props:int/1`)
- *The following properties should hold upon exit:*
  `Primes` is a list of integers. (`numlists:intlist/1`)

intlist/1: REGTYPE

Usage: `intlist(X)`

- *Description:* `X` is a list of integers.

numlist/1: REGTYPE

Usage: `numlist(X)`

- *Description:* `X` is a list of numbers.

sum_list/2: PREDICATE

Usage: `sum_list(List,N)`

- *Description:* `N` is the total sum of the elements of `List`.

- *The following properties should hold at call time:*
  `List` is a list of numbers. (`numlists:numlist/1`)
- *The following properties should hold upon exit:*
  `N` is a number. (`basic_props:num/1`)

sum_list/3: PREDICATE

Usage: `sum_list(List,N0,N)`

- *Description:* `N` is the total sum of the elements of `List` plus `N0`.
- *The following properties should hold at call time:*
  `List` is a list of numbers. (`numlists:numlist/1`)
  `N0` is a number. (`basic_props:num/1`)
- *The following properties should hold upon exit:*
  `N` is a number. (`basic_props:num/1`)

sum_list_of_lists/2: PREDICATE

Usage: `sum_list_of_lists(Lists,N)`

- *Description:* `N` is the total sum of the elements of the lists of `Lists`.
- *The following properties should hold at call time:*
  `List` is a list of `numlists`. (`basic_props:list/2`)
- *The following properties should hold upon exit:*
  `N` is a number. (`basic_props:num/1`)

sum_list_of_lists/3: PREDICATE

Usage: `sum_list_of_lists(Lists,N0,N)`

- *Description:* `N` is the total sum of the elements of the lists of `Lists` plus `N0`.
- *The following properties should hold at call time:*
  `List` is a list of `numlists`. (`basic_props:list/2`)
  `N0` is a number. (`basic_props:num/1`)
- *The following properties should hold upon exit:*
  `N` is a number. (`basic_props:num/1`)

149 Pattern (regular expression) matching

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.3#49 (1999/9/8, 21:8:9 MEST)

This library provides facilities for matching strings and terms against *patterns* (i.e., *regular expressions*).

149.1 Usage and interface (patterns)

- **Library usage:**
  `:- use_module(library(patterns)).`
- **Exports:**
  - *Predicates:*
    `match_pattern/2`, `match_pattern/3`, `case_insensitive_match/2`, `letter_match/2`, `match_pattern_pred/2`.
  - *Regular Types:*
    `pattern/1`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

149.2 Documentation on exports (patterns)

match_pattern/2: PREDICATE

Usage: `match_pattern(Pattern,String)`

- *Description:* Matches `String` against `Pattern`. For example, `match_pattern("*.pl","foo.pl")` succeeds.
- *The following properties should hold at call time:*

`Pattern` is a pattern to match against. (`patterns:pattern/1`)

`String` is a string (a list of character codes). (`basic_props:string/1`)

match_pattern/3: PREDICATE

Usage: `match_pattern(Pattern,String,Tail)`

- *Description:* Matches `String` against `Pattern`. `Tail` is the remainder of the string after the match. For example, `match_pattern("??*","foo.pl",Tail)` succeeds, instantiating `Tail` to `"o.pl"`.
- *The following properties should hold at call time:*

`Pattern` is a pattern to match against. (`patterns:pattern/1`)

`String` is a string (a list of character codes). (`basic_props:string/1`)

`Tail` is a string (a list of character codes). (`basic_props:string/1`)

case_insensitive_match/2: PREDICATE

Usage: `case_insensitive_match(Pred1,Pred2)`

– *Description:* Tests if two predicates `Pred1` and `Pred2` match in a case-insensitive way.

letter_match/2: PREDICATE

No further documentation available for this predicate.

pattern/1: REGTYPE

Special characters for `Pattern` are:

*	Matches any string, including the null string.
?	Matches any single character.
[...]	Matches any one of the enclosed characters. A pair of characters separated by a minus sign denotes a range; any character lexically between those two characters, inclusive, is matched. If the first character following the [is a ^ then any character not enclosed is matched. No other character is special inside this construct. To include a] in a character set, you must make it the first character. To include a '-', you must use it in a context where it cannot possibly indicate a range: that is, as the first character, or immediately after a range.
|	specifies an alternative. Two regular expressions A and B with | in between form an expression that matches anything that either A or B will match.
{...}	groups alternatives inside larger patterns.
\	Quotes a special character (including itself).

Usage: `pattern(P)`

– *Description:* `P` is a pattern to match against.

match_pattern_pred/2: PREDICATE

Usage: `match_pattern_pred(Pred1,Pred2)`

– *Description:* Tests if two predicates `Pred1` and `Pred2` match using regular expressions.

150 Graphs

Author(s): F. Bueno.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.5#83 (2000/3/23, 19:23:58 CET)

150.1 Usage and interface (graphs)

- **Library usage:**
  `:- use_module(library(graphs)).`
- **Exports:**
  - *Predicates:*
    `dgraph_to_ugraph/2`, `dlgraph_to_lgraph/2`, `edges_to_ugraph/2`, `edges_to_lgraph/2`.
  - *Regular Types:*
    `dgraph/1`, `dlgraph/1`.
- **Other modules used:**
  - *System library modules:*
    `sort`, `graphs/ugraphs`, `graphs/lgraphs`.

150.2 Documentation on exports (graphs)

dgraph/1: REGTYPE

`dgraph(Graph)`

A directed graph is a term `graph(V,E)` where `V` is a list of vertices and `E` is a list of edges (none necessarily sorted). Edges are pairs of vertices which are directed, i.e., `(a,b)` represents `a->b`. Two vertices `a` and `b` are equal only if `a==b`.

Usage: `dgraph(Graph)`

- *Description:* `Graph` is a directed graph.

dlgraph/1: REGTYPE

`dlgraph(Graph)`

A labeled directed graph is a directed graph where edges are triples of the form `(a,l,b)` where `l` is the label of the edge `(a,b)`.

Usage: `dlgraph(Graph)`

- *Description:* `Graph` is a directed labeled graph.

dgraph_to_ugraph/2: PREDICATE

Usage: `dgraph_to_ugraph(+Graph,-UGraph)`

- *Description:* Converts `Graph` to `UGraph`.

- *The following properties should hold at call time:*
  `+Graph` is a directed graph. (`graphs:dgraph/1`)
  `-UGraph` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*
  `+Graph` is a directed graph. (`graphs:dgraph/1`)
  `-UGraph` is an ugraph. (`ugraphs:ugraph/1`)

dlgraph_to_lgraph/2: PREDICATE

Usage: `dlgraph_to_lgraph(+Graph,-LGraph)`

- *Description:* Converts `Edges` to `LGraph`.
- *The following properties should hold at call time:*
  `+Graph` is a directed labeled graph. (`graphs:dlgraph/1`)
  `-LGraph` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*
  `+Graph` is a directed labeled graph. (`graphs:dlgraph/1`)
  `-LGraph` is a labeled graph of `term` terms. (`lgraphs:lgraph/2`)

edges_to_ugraph/2: PREDICATE

Usage: `edges_to_ugraph(+Edges,-UGraph)`

- *Description:* Converts `Graph` to `UGraph`.
- *The following properties should hold at call time:*
  `+Edges` is a list of `pair`s. (`basic_props:list/2`)
  `-UGraph` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*
  `+Edges` is a list of `pair`s. (`basic_props:list/2`)
  `-UGraph` is an ugraph. (`ugraphs:ugraph/1`)

edges_to_lgraph/2: PREDICATE

Usage: `edges_to_lgraph(+Edges,-LGraph)`

- *Description:* Converts `Edges` to `LGraph`.
- *The following properties should hold at call time:*
  `+Edges` is a list of `triple`s. (`basic_props:list/2`)
  `-LGraph` is a free variable. (`term_typing:var/1`)
- *The following properties should hold upon exit:*
  `+Edges` is a list of `triple`s. (`basic_props:list/2`)
  `-LGraph` is a labeled graph of `term` terms. (`lgraphs:lgraph/2`)

150.3 Documentation on internals (graphs)

pair/1: REGTYPE

Usage: `pair(P)`

– *Description:* `P` is a pair `(_,_)`.

triple/1: REGTYPE

Usage: `triple(P)`

– *Description:* `P` is a triple `(_,_,_)`.

151 Unweighted graph-processing utilities

Author(s): M. Carlsson, adapted from shared code written by Richard A O'Keefe. Mods by F.Bueno and M.Carro..

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 0.9#105 (1999/6/4, 12:24:49 MEST)

An unweighted directed graph (ugraph) is represented as a list of (vertex-neighbors) pairs, where the pairs are in standard order (as produced by keysort with unique keys) and the neighbors of each vertex are also in standard order (as produced by sort), and every neighbor appears as a vertex even if it has no neighbors itself.

An undirected graph is represented as a directed graph where for each edge `(U,V)` there is a symmetric edge `(V,U)`.

An edge `(U,V)` is represented as the term `U-V`.

A vertex can be any term. Two vertices are distinct iff they are not identical (`==/2`).

A path is represented as a list of vertices. No vertex can appear twice in a path.

151.1 Usage and interface (ugraphs)

- **Library usage:**
  `:- use_module(library(ugraphs)).`
- **Exports:**
  - *Predicates:*
    `vertices_edges_to_ugraph/3`, `neighbors/3`, `edges/2`, `del_vertices/3`, `vertices/2`, `add_vertices/3`, `add_edges/3`, `transpose/2`, `point_to/3`.
  - *Regular Types:*
    `ugraph/1`.
- **Other modules used:**
  - *System library modules:*
    `sets`, `sort`.

151.2 Documentation on exports (ugraphs)

vertices_edges_to_ugraph/3: PREDICATE

No further documentation available for this predicate.

neighbors/3: PREDICATE

Usage: `neighbors(+Vertex,+Graph,-Neighbors)`

- *Description:* Is true if `Vertex` is a vertex in `Graph` and `Neighbors` are its neighbors.

edges/2: PREDICATE

Usage: `edges(+Graph,-Edges)`

– *Description:* Unifies `Edges` with the edges in `Graph`.

del_vertices/3: PREDICATE

Usage: `del_vertices(+Graph1,+Vertices,-Graph2)`

– *Description:* Is true if `Graph2` is `Graph1` with `Vertices` and all edges to and from `Vertices` removed from it.

vertices/2: PREDICATE

Usage: `vertices(+Graph,-Vertices)`

– *Description:* Unifies `Vertices` with the vertices in `Graph`.

add_vertices/3: PREDICATE

Usage: `add_vertices(+Graph1,+Vertices,-Graph2)`

– *Description:* Is true if `Graph2` is `Graph1` with `Vertices` added to it.

add_edges/3: PREDICATE

Usage: `add_edges(+Graph1,+Edges,-Graph2)`

– *Description:* Is true if `Graph2` is `Graph1` with `Edges` and their 'to' and 'from' vertices added to it.

transpose/2: PREDICATE

Usage: `transpose(+Graph,-Transpose)`

– *Description:* Is true if `Transpose` is the graph computed by replacing each edge `(u,v)` in `Graph` by its symmetric edge `(v,u)`. It can only be used one way around. The cost is O(N^2).

point_to/3: PREDICATE

Usage: `point_to(+Vertex,+Graph,-Point_to)`

– *Description:* Is true if `Point_to` is the list of nodes which go directly to `Vertex` in `Graph`.

ugraph/1: REGTYPE

Usage: `ugraph(Graph)`

– *Description:* `Graph` is an ugraph.

152 wgraphs (library)

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 0.4#5 (1998/2/24)

152.1 Usage and interface (wgraphs)

- **Library usage:**
  `:- use_module(library(wgraphs)).`
- **Exports:**
  - *Predicates:*
    `vertices_edges_to_wgraph/3`.
- **Other modules used:**
  - *System library modules:*
    `sets`, `sort`.

152.2 Documentation on exports (wgraphs)

vertices_edges_to_wgraph/3: PREDICATE

No further documentation available for this predicate.

153 Labeled graph-processing utilities

Author(s): F. Bueno.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
See the comments for the `ugraphs` library.

153.1 Usage and interface (`lgraphs`)

- **Library usage:**
  `:- use_module(library(lgraphs)).`
- **Exports:**
  - *Predicates:*
    `vertices_edges_to_lgraph/3`.
  - *Regular Types:*
    `lgraph/2`.
- **Other modules used:**
  - *System library modules:*
    `sort`, `sets`.

153.2 Documentation on exports (`lgraphs`)

lgraph/2: REGTYPE

Usage: `lgraph(Graph,Type)`

- *Description:* `Graph` is a labeled graph of `Type` terms.

vertices_edges_to_lgraph/3: PREDICATE

No further documentation available for this predicate.

154 queues (library)

Version: 0.4#5 (1998/2/24)

154.1 Usage and interface (queues)

- **Library usage:**
  `:- use_module(library(queues)).`
- **Exports:**
  - *Predicates:*
    `q_empty/1`, `q_insert/3`, `q_member/2`, `q_delete/3`.

154.2 Documentation on exports (queues)

q_empty/1: PREDICATE

No further documentation available for this predicate.

q_insert/3: PREDICATE

No further documentation available for this predicate.

q_member/2: PREDICATE

No further documentation available for this predicate.

q_delete/3: PREDICATE

No further documentation available for this predicate.

155 Random numbers

Author(s): Daniel Cabeza.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#194 (2002/4/4, 21:8:41 CEST)
This module provides predicates for generating pseudo-random numbers

155.1 Usage and interface (random)

- **Library usage:**
  `:- use_module(library(random)).`
- **Exports:**
  - *Predicates:*
    `random/1`, `random/3`, `srandom/1`.

155.2 Documentation on exports (random)

random/1: PREDICATE

`random(Number)`

`Number` is a (pseudo-) random number in the range [0.0,1.0]

random/3: PREDICATE

`random(Low,Up,Number)`

`Number` is a (pseudo-) random number in the range [`Low`, `Up`]

Usage 1: `random(+int,+int,-int)`

- *Description:* If `Low` and `Up` are integers, `Number` is an integer.

srandom/1: PREDICATE

`srandom(Seed)`

Changes the sequence of pseudo-random numbers according to `Seed`. The stating sequence of numbers generated can be duplicated by calling the predicate with `Seed` unbound (the sequence depends on the OS).

156 sets (library)

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 0.9#17 (1999/3/23, 20:57:20 MET)
This module implements set operations. Sets are just ordered lists.

156.1 Usage and interface (sets)

- **Library usage:**
  `:- use_module(library(sets)).`
- **Exports:**
  - *Predicates:*
    `insert/3`, `ord_delete/3`, `ord_member/2`, `ord_test_member/3`, `ord_subtract/3`, `ord_intersection/3`, `ord_intersection_diff/4`, `ord_intersect/2`, `ord_subset/2`, `ord_subset_diff/3`, `ord_union/3`, `ord_union_diff/4`, `ord_union_symdiff/4`, `ord_union_change/3`, `merge/3`, `ord_disjoint/2`, `setproduct/3`.
- **Other modules used:**
  - *System library modules:*
    `sort`.

156.2 Documentation on exports (sets)

insert/3: PREDICATE

Usage: `insert(+Set1,+Element,-Set2)`

- *Description:* It is true when `Set2` is `Set1` with `Element` inserted in it, preserving the order.

ord_delete/3: PREDICATE

Usage: `ord_delete(+Set0,+X,-Set)`

- *Description:* It succeeds if `Set` is `Set0` without element `X`.

ord_member/2: PREDICATE

Usage: `ord_member(+X,+Set)`

- *Description:* It succeeds if `X` is member of `Set`.

ord_test_member/3: PREDICATE

Usage: `ord_test_member(+Set,+X,-Result)`

- *Description:* If `X` is member of `Set` then `Result`=`yes`. Otherwise `Result`=`no`.

ord_subtract/3: PREDICATE

Usage: `ord_subtract(+Set1,+Set2,?Difference)`

– *Description:* It is true when `Difference` contains all and only the elements of `Set1` which are not also in `Set2`.

ord_intersection/3: PREDICATE

Usage: `ord_intersection(+Set1,+Set2,?Intersection)`

– *Description:* It is true when `Intersection` is the ordered representation of `Set1` and `Set2`, provided that `Set1` and `Set2` are ordered lists.

ord_intersection_diff/4: PREDICATE

Usage: `ord_intersection_diff(+Set1,+Set2,-Intersect,-NotIntersect)`

– *Description:* `Intersect` contains those elements which are both in `Set1` and `Set2`, and `NotIntersect` those which are in `Set1` but not in `Set2`.

ord_intersect/2: PREDICATE

Usage: `ord_intersect(+Xs,+Ys)`

– *Description:* Succeeds when the two ordered lists have at least one element in common.

ord_subset/2: PREDICATE

Usage: `ord_subset(+Xs,+Ys)`

– *Description:* Succeeds when every element of `Xs` appears in `Ys`.

ord_subset_diff/3: PREDICATE

Usage: `ord_subset_diff(+Set1,+Set2,-Difference)`

– *Description:* It succeeds when every element of `Set1` appears in `Set2` and `Difference` has the elements of `Set2` which are not in `Set1`.

ord_union/3: PREDICATE

Usage: `ord_union(+Set1,+Set2,?Union)`

– *Description:* It is true when `Union` is the union of `Set1` and `Set2`. When some element occurs in both sets, `Union` retains only one copy.

ord_union_diff/4: PREDICATE

Usage: `ord_union_diff(+Set1,+Set2,-Union,-Difference)`

– *Description:* It succeeds when `Union` is the union of `Set1` and `Set2`, and `Difference` is `Set2` set-minus `Set1`.

ord_union_symdiff/4: PREDICATE

Usage: `ord_union_symdiff(+Set1,+Set2,-Union,-Diff)`

– *Description:* It is true when Diff is the symmetric difference of Set1 and Set2, and Union is the union of Set1 and Set2.

ord_union_change/3: PREDICATE

Usage: `ord_union_change(+Set1,+Set2,-Union)`

– *Description:* `Union` is the union of `Set1` and `Set2` and `Union` is different from `Set2`.

merge/3: PREDICATE

Usage: `merge(+Set1,+Set2,?Union)`

– *Description:* See `ord_union/3`.

ord_disjoint/2: PREDICATE

Usage: `ord_disjoint(+Set1,+Set2)`

– *Description:* `Set1` and `Set2` have no element in common.

setproduct/3: PREDICATE

Usage: `setproduct(+Set1,+Set2,-Product)`

– *Description:* `Product` has all two element sets such that one element is in `Set1` and the other in `set2`, except that if the same element belongs to both, then the corresponding one element set is in `Product`.

157 Variable name dictionaries

Author(s): Francisco Bueno.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 0.8#19 (1998/12/3, 12:53:16 MET)

157.1 Usage and interface (vndict)

- **Library usage:**
  `:- use_module(library(vndict)).`
- **Exports:**
  - *Predicates:*
    `create_dict/2`, `complete_dict/3`, `complete_vars_dict/3`, `prune_dict/3`, `dict2varnamesl/2`, `varnamesl2dict/2`, `find_name/4`, `rename/2`, `vars_names_dict/3`.
  - *Regular Types:*
    `null_dict/1`, `varname/1`, `varnamesl/1`, `varnamedict/1`.
- **Other modules used:**
  - *System library modules:*
    `idlists`, `terms_vars`, `sets`, `sort`.

157.2 Documentation on exports (vndict)

null_dict/1: REGTYPE

Usage: `null_dict(D)`

- *Description:* `D` is an empty dictionary.

create_dict/2: PREDICATE

Usage: `create_dict(Term,Dict)`

- *Description:* `Dict` has names for all variables in `Term`.
- *The following properties should hold at call time:*
  `Term` is any term. (`basic_props:term/1`)
- *The following properties should hold upon exit:*
  `Dict` is a dictionary of variable names. (`vndict:varnamedict/1`)

complete_dict/3: PREDICATE

Usage: `complete_dict(+Dict,+Term,-NewDict)`

- *Description:* `NewDict` is `Dict` augmented with the variables of `Term` not yet in `Dict`.

complete_vars_dict/3: PREDICATE

Usage: `complete_vars_dict(+Dict,+Vars,-NewDict)`

- *Description:* `NewDict` is `Dict` augmented with the variables of the list `Vars` not yet in `Dict`.

prune_dict/3: PREDICATE

Usage: `prune_dict(+Term,+Dict,-NewDict)`

- *Description:* `NewDict` is `Dict` reduced to just the variables of `Term`.

dict2varnamesl/2: PREDICATE

Usage: `dict2varnamesl(Dict,VNs)`

- *Description:* Translates `Dict` to `VNs`.
- *The following properties should hold at call time:*

  `Dict` is a dictionary of variable names. (`vndict:varnamedict/1`)
- *The following properties should hold upon exit:*

  `VNs` is a list of `Name=Var`, for a variable `Var` and its name `Name`. (`vndict:varnamesl/1`)

varnamesl2dict/2: PREDICATE

Usage: `varnamesl2dict(VNs,Dict)`

- *Description:* Translates `VNs` to `Dict`.
- *The following properties should hold at call time:*

  `VNs` is a list of `Name=Var`, for a variable `Var` and its name `Name`. (`vndict:varnamesl/1`)
- *The following properties should hold upon exit:*

  `Dict` is a dictionary of variable names. (`vndict:varnamedict/1`)

find_name/4: PREDICATE

`find_name(Vars,Names,V,Name)`

Given that `vars_names_dict(Dict,Vars,Names)` holds, it acts as `rename(X,Dict)`, but the name of `X` is given as `Name` instead of unified with it.

rename/2: PREDICATE

Usage: `rename(Term,Dict)`

- *Description:* Unifies each variable in `Term` with its name in `Dict`. If no name is found, a new name is created.
- *The following properties should hold at call time:*

  `Dict` is a dictionary of variable names. (`vndict:varnamedict/1`)

varname/1: REGTYPE

Usage: `varname(N)`

- *Description:* `N` is term representing a variable name.

varnamesl/1: REGTYPE

Usage: `varnamesl(D)`

- *Description:* `D` is a list of `Name=Var`, for a variable `Var` and its name `Name`.

varnamedict/1: REGTYPE

Usage: `varnamedict(D)`

- *Description:* `D` is a dictionary of variable names.

vars_names_dict/3: PREDICATE

Usage: `vars_names_dict(Dict,Vars,Names)`

- *Description:* `Varss` is a sorted list of variables, and `Names` is a list of their names, which correspond in the same order.
- *Call and exit should be compatible with:*

  `Dict` is a dictionary of variable names. (`vndict:varnamedict/1`)

  `Vars` is a list. (`basic_props:list/1`)

  `Names` is a list. (`basic_props:list/1`)

PART X - Miscellaneous standalone utilities

Author(s): clip@clip.dia.fi.upm.es, http://www.clip.dia.fi.upm.es/, The CLIP Group, School of Computer Science, Technical University of Madrid.

This is the documentation for a set of miscellaneous standalone utilities contained in the `etc` directory of the Ciao distribution.

158 A Program to Help Cleaning your Directories

Author(s): Manuel Carro.

Version: 0.1#3 (2001/10/25, 14:31:59 CEST)

A simple program for traversing a directory tree and deciding which files may be deleted in order to save space and not to loose information.

158.1 Usage (cleandirs)

```
cleandirs: <initial_dir> <delete_options> <backup_options>
cleandirs explores <initial_dir> (which should be an absolute path)
and looks for backup files and files which can be generated from other
files, using a plausible heuristic aimed at retaining the same amount
of information while recovering some disk space.  The heuristic is
based on the extension of the filename.

Delete options is one of:
   --list: just list the files/directories which are amenable to be deleted,
           but do not delete them. SAFE.
    --ask: list the files/directories and ask for deletion. UNSAFE if you
           make a mistake.
 --delete: just delete the files/directories without asking.  I envy your
           brave soul if you choose this option.

Backup options is one of:
 --includebackups: include backup files in the list of files to check.
 --excludebackups: do not include backup files in the list of files to check.
    --onlybackups: include only backup files in the list of files to check.

Symbolic links are not traversed.  Special files are not checked.
```

Invoking the program with no arguments will return an up-to-date information on the options.

158.2 Known bugs and planned improvements (cleandirs)

- Recursive removal of subdirectories relies on the existence of a recursive /bin/rm command in your system.

159 Printing the declarations and code in a file

Author(s): Manuel Hermenegildo.

Version: 0.5#6 (1999/4/15, 20:33:6 MEST)

A simple program for printing assertion information (predicate declarations, property declarations, type declarations, etc.) and printing code-related information (imports, exports, libraries used, etc.) on a file. The file should be a single CIAO or Prolog source file. It uses the CIAO compiler's pass one to do it. This program is specially useful for example to check what the compiler is actually seeing after syntactic expansions, as well as for checking what assertions the assertion normalizer is producing from the original assertions in the file.

159.1 Usage (fileinfo)

```
fileinfo -asr <filename.asr>
   : pretty prints the contents of <filename.asr>

fileinfo [-v] [-m] <-a|-c|-e> <filename> [libdir1] ... [libdirN]
-v : verbose output (e.g., lists all files read)
-m : restrict info to current module
-a : print assertions
-c : print code and interface (imports/exports, etc.)
-e : print only errors - useful to check syntax of assertions in file

fileinfo -h
   : print this information
```

159.2 More detailed explanation of options (fileinfo)

- If the `-a` option is selected, `fileinfo` prints the assertions (only code-oriented assertions – not comment-oriented assertions) in the file *after normalization*. If the `-c` option is selected `fileinfo` prints the file interface, the declarations contained in the file, and the actual code. If the `-e` option is selected `fileinfo` prints only any sintactic and import-export errors found in the file, including the assertions.
- `filename` must be the name of a Prolog or CIAO source file.
- This filename can be followed by other arguments which will be taken to be library directory paths in which to look for files used by the file being analyzed.
- If the `-m` option is selected, only the information related to the current module is printed.
- The `-v` option produces verbose output. This is very useful for debugging, since all the files accessed during assertion normalization are listed.
- In the `-asr` usage, `fileinfo` can be used to print the contents of a `.asr` file in human-readable form.

160 Printing the contents of a bytecode file

Author(s): Daniel Cabeza.

Version: 0.5#2 (1999/11/11, 19:20:50 MET)

This simple program takes as an argument a bytecode (.po) file and prints out in symbolic form the information contained in the file. It uses compiler and engine builtins to do so, so that it keeps track with changes in bytecode format.

160.1 Usage (viewpo)

```
viewpo <file1>.po
   : print .po contents in symbolic form

viewpo -h
   : print this information
```

161 Crossed-references of a program

Author(s): Francisco Bueno.

The `xrefs` crossed-references Ciao library includes several modules which allow displaying crossed-references of the code in a program. Crossed-references identify modules which import code from other modules, or files (be them modules or not) which use code in other files. Crossed-references can be obtained as a term representing a graph, displayed graphically (using daVinci, a graph displayer developed by U. of Bremen, Germany), or printed as a list.

The libraries involved are as follows:

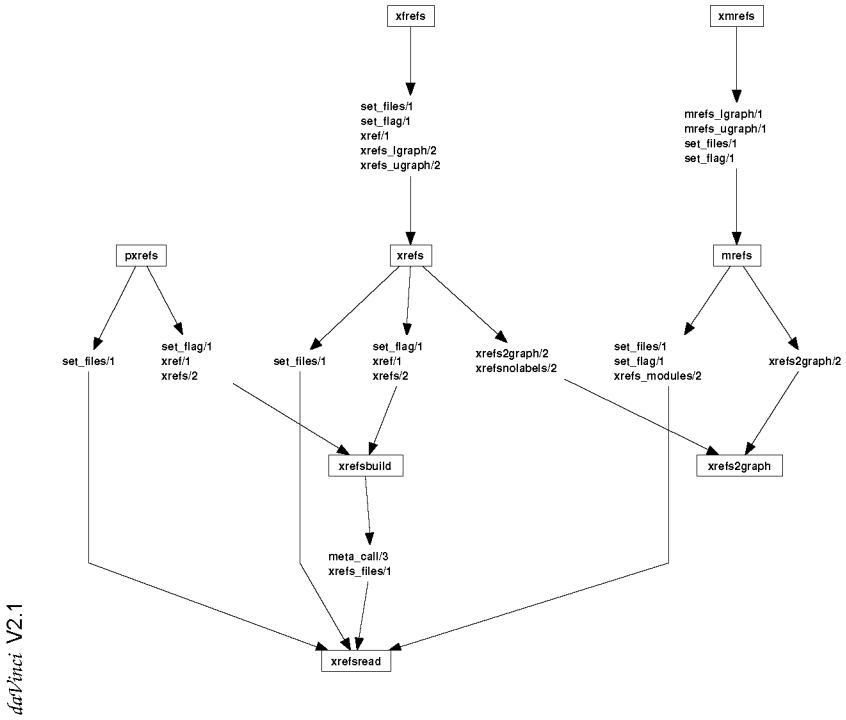
- `etc(xmrefs)` displays a graph of crossed-references between modules using daVinci,
- `etc(xfrefs)` displays a graph of crossed-references between files using daVinci,
- `library(xrefs)` obtains a graph of crossed-references between files,
- `library('xrefs/mrefs')` obtains a graph of crossed-references between modules,
- `library('xrefs/pxrefs')` prints a list of crossed-references between files.

The first two are intended to be used by loading in `ciaosh`. The other three are intended to be used as modules within an application.

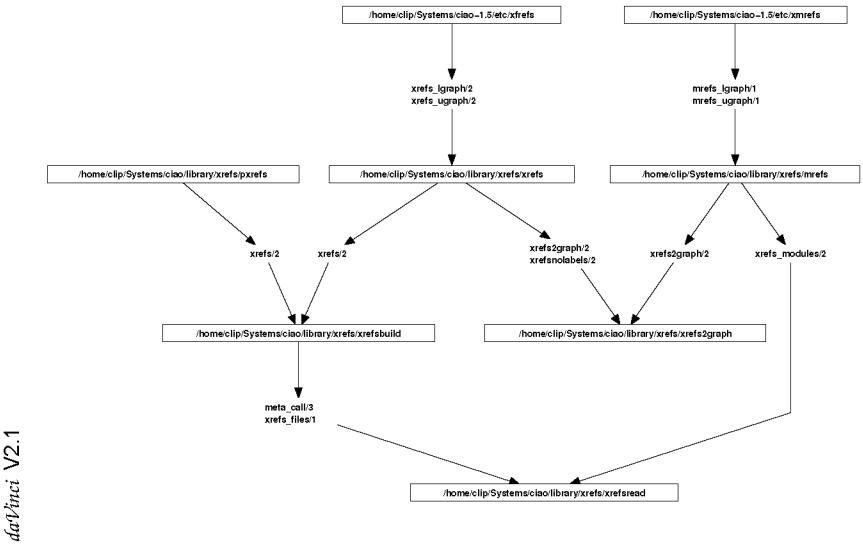
The following is an example graph of the library modules involved in the crossed-references application. It has been obtained with:

```
[ciao/etc]> ciaosh
Ciao-Prolog 1.5 #24: Tue Dec 28 14:12:11 CET 1999
?- use_module(xmrefs).

yes
?- set_flag(X).

X = 3 ?

yes
?- set_files([xfrefs, xmrefs,
              library(xrefs),
              library('xrefs/mrefs'),
              library('xrefs/pxrefs'),
              library('xrefs/xrefs2graph'),
              library('xrefs/xrefsbuild'),
              library('xrefs/xrefsread')
     ]).

yes
?- xmrefs.
```

so that it is displayed by daVinci as:



The following is an example graph of the same module files, where crossed-references have been obtained with `xfrefs:xfrefs(whodefs)` instead of `xmrefs:xmrefs`:



For more information refer to the xrefs documentation (`xrefs_doc.dvi`) in the source library of the Ciao distribution.

162 Gathering the dependent files for a file

Author(s): Daniel Cabeza, Manuel Hermenegildo.

Version: 1.0#6 (1998/11/5, 13:56:58 MET)

This simple program takes a single Ciao or Prolog source filename (which is typically the main file of an application). It prints out the list of all the dependent files, i.e., all files needed in order to build the application, including those which reside in libraries. This is particularly useful in Makefiles, for building standalone distributions (e.g., .tar files) automatically.

The filename should be followed by other arguments which will be taken to be library directory paths in which to look for files used by the file being analyzed.

162.1 Usage (get_deps)

```
get_deps [-u <filename>] <filename> [lib_dir1] ... [lib_dirN]
           : return dependent files for <filename>
             found in [lib_dir1] ... [lib_dirN]

get_deps -h
           : print this information
```

163 Finding differences between two Prolog files

Author(s): Francisco Bueno.

This simple program works like the good old diff but for files that contain Prolog code. It prints out the clauses that it finds are different in the files. Its use avoids textual differences such as different variable names and different formatting of the code in the files.

163.1 Usage (pldiff)

```
pldiff <file1> <file2>
   : find differences

pldiff -h
   : print this information
```

but you can also use the program as a library and invoke the predicate:

```
pldiff( <filename> , <filename> )
```

163.2 Known bugs and planned improvements (`pldiff`)

- Currently uses variant/2 to compare clauses. This is useful, but there should be an option to select the way clauses are compared, e.g., some form of equivalence defined by the user.

164 The Ciao lpmake scripting facility

Author(s): Manuel Hermenegildo, clip@dia.fi.upm.es, http://www.clip.dia.fi.upm.es/, The CLIP Group, Facultad de Informática, Universidad Politécnica de Madrid.

Note: `lpmake` and the `make` library are still under active development, and they may change substantially in future releases.

`lpmake` is a Ciao application which uses the Ciao `make` library to implement a dependency-driven scripts in a similar way to the Un*x `make` facility.

The original purpose of the Un*x `make` utility is to determine automatically which pieces of a large program needed to be recompiled, and issue the commands to recompile them. In practice, `make` is often used for many other purposes: it can be used to describe any task where some files must be updated automatically from others whenever the others change. `lpmake` can be used for the same types of applications as `make`, and also for some new ones, and offers a number of advantages over `make`. The first one is *portability*. When compiled to a bytecode executable `lpmake` runs on any platform where a Ciao engine is available. Also, the fact that typically many of the operations are programmed in Prolog within the makefile, not needing external applications, improves portability further. The second advantage of `lpmake` is *improved programming capabilities*. While `lpmake` is simpler than `make`, `lpmake` allows using the Ciao Prolog language within the scripts. This allows establising more complex dependencies and programming powerful operations within the make file, and without resorting to external packages (e.g., operating system commands), which also helps portability. A final advantage of `lpmake` is that it supports a form of *autodocumentation*: comments associated to targets can be included in the configuration files. Calling `lpmake` in a directory which has such a configuration file explains what commands the configuration file support and what these commands will do.

164.1 General operation

To prepare to use `lpmake`, and in a similar way to `make`, you must write a file (typically called `Makefile.pl`) that describes the relationships among files in your program or application, and states the commands for updating each file. In a program, typically the executable file is updated from object files, which are in turn made by compiling source files. Another example is running `latex` and `dvips` on a set of source `.tex` files to generate a document in `dvi` and `postscript` formats. Once a suitable makefile exists, each time you change some source files, simply typing `lpmake` suffices to perform all necessary operations (recompilations, processing text files, etc.). The `lpmake` program uses the dependency rules in the makefile and the last modification times of the files to decide which of the files need to be updated. For each of those files, it issues the commands recorded in the makefile. For example, in the `latex/ dvips` case one rule states that the `.dvi` file whould be updated from the `.tex` files whenever one of them changes and another rule states that the `.ps` file needs to be updated from a `.dvi` file every time it changes. The rule also describe the commands to be issued to update the files.

So, the general process is as follows: `lpmake` executes commands in the `Makefile.pl` to update one or more target *names*, where *name* is often a program, but can also be a file to be generated or even a "virtual" target. If no `-l` or `-m` options are present, `lpmake` will look for the makefile `Makefile.pl`. `lpmake` updates a target if it depends on prerequisite files that have been modified since the target was last modified, or if the target does not exist. You can provide command line arguments to `lpmake` to control which files should be regenerated, or how.

164.2 lpmake usage

```
Supported command line options:

[-v] [-u <.../Configfile.pl>] <command1> ... <commandn>

  Process commands <command1> ... <commandn>, using user
  file <.../Configfile.pl> as configuration file. If no
  configuration file is specified a file 'Makefile.pl' in
  the current directory will be used.

[-v] [-m <.../Configfile.pl>] <command1> ... <commandn>

  Same as above, but the configuration file is a module.
  Making this file a module is useful to implement
  inherintance across diferent configuration files, i.e.,
  the values declared in a configuration file can be
  easily made to override those defined in another.

  Optional argument '-v' produces verbose output, reporting
  on the processing of the dependency rules. Very useful
  for debugging Makefiles.

-h     [ -u <.../Configfile.pl> ]
-h     [ -m <.../Configfile.pl> ]
-help  [ -u <.../Configfile.pl> ]
-help  [ -m <.../Configfile.pl> ]

  Print this help message. If a configuration file is given,
  and the commands in it are commented, then information on
  these commands is also printed.
```

164.3 Acknowledgments (lpmake)

Some parts of the documentation are taken from the documentation of GNU's gmake.

165 Find out which architecture we are running on

Author(s): Manuel Carro, Robert Manchek.

Version: 0.0#6 (2001/3/26, 13:56:52 CEST)

The architecure and operating system the engine is compiled for determines whether we can use or not certain libraries. This script, taken from a PVM distribution, uses a heuristic (which may need to be tuned from time to time) to find out the platform. It returns a string which is used throughout the engine (in #ifdefs) to enable/disable certain characteristics.

165.1 Usage (ciao_get_arch)

```
Usage: ciao_get_arch
```

165.2 More details

Look at the script itself...

PART XI - Contributed libraries

This part includes a number of libraries which have contributed by users of the Ciao system. Over time, some of these libraries are moved to the main library directories of the system.

166 Programming MYCIN rules

Author(s): Angel Fernandez Pineda.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#59 (2000/2/29, 14:51:54 CET)

MYCIN databases are declared as Prolog modules containing mycin rules. Those rules are given a *certainty factor* (*CF*) which denotates an expert's credibility on that rule:

- A value of -1 stands for *surely not.*
- A value of 1 stands for *certainly.*
- A value of 0 stands for *I don't know.*

Intermediate values are allowed.

Mycin rules work on a different way as Prolog clauses: a rule will never fail (in the Prolog sense), it will return a certainty value instead. As a consequence **all** mycin rules will be explored during inference, so the order in which rules are written is not significant. For this reason, the usage of the Prolog *cut* (!) is discouraged.

166.1 Usage and interface (`mycin`)

- **Library usage:**

  In order to declare a mycin database you must include the following declaration as the first one in your file:

  ```
  :- mycin(MycinDataBaseName).
  ```

- **New declarations defined:**

  `export/1`.

166.2 Documentation on new declarations (`mycin`)

export/1: DECLARATION

This directive allows a given mycin predicate to be called from Prolog programs. The way in which mycin rules are called departs from Prolog ones. For instance, the followin mycin predicate:

```
:- export p/1.
```

must be called from Prolog Programs as: `mycin(p(X),CF)`, where CF will be binded to the resulting certainty factor. Obviously, the variables on *P/1* may be instantiated as you wish. Since the Prolog predicate *mycin/2* may be imported from several mycin databases, it is recommended to fully qualify those predicate goals. For example : `mydatabase:mycin(p(X),CF)`.

Usage: `:- export(Spec).`

- *Description:* `Spec` will be a callable mycin predicate.

166.3 Known bugs and planned improvements (`mycin`)

- Not fully implemented.
- Dynamic mycin predicates not implemented: open question.
- Importation of user-defined mycin predicates requires further design. This includes importation of mycin databases from another mycin database.

167 A Chart Library

Author(s): Isabel Martín García.

This library is intended to eaose the task of displaying some graphical results. This library allows the programmer to visualize different graphs and tables without knowing anything about specific graphical packages.

You need to install the BLT package in your computer. BLT is an extension to the Tk toolkit and it does not require any patching of the Tcl or Tk source files. You can find it in `http://www.tcltk.com/blt/index.html`

Basically, when the user invokes a predicate, the library (internally) creates a bltwish interpreter and passes the information through a socket to display the required widget. The interpreter parses the received commands and executes them.

The predicates exported by this library can be classified in four main groups, according to the types of representation they provide.

- bar charts
- line graphs
- scatter graphs
- tables

To represent graphs, the Cartesian coordinate system is used. I have tried to show simple samples for every library exported predicate in order to indicate how to call them.

167.1 Bar charts

In this section we shall introduce the general issues about the set of barchart predicates. By calling the predicates that pertain to this group a bar chart for plotting two-dimensional data (X-Y coordinates) can be created. A bar chart is a graphic means of comparing numbers by displaying bars of lengths proportional to the y-coordinates they represented. The barchart widget has many configurable options such as title, header text, legend and so on. You can configure the appearance of the bars as well. The bar chart widget has the following components:

Header text
: The text displayed at the top of the window. If it is `''` no text will be displayed.

Save button
: The button placed below the header text. Pops up a dialog box for the user to select a file to save the graphic in PostScript format.[1]

Bar chart title
: The title of the graph. It is displayed at the top of the bar chart graph. If text is `''` no title will be displayed.

X axis title
: X axis title. If text is `''` no x axis title will be displayed.

Y axis title
: Y axis title. If text is `''` no y axis title will be displayed.

X axis
: X coordinate axis. The x axis is drawn at the bottom margin of the bar chart graph. The x axis consists of the axis line, ticks and tick labels. Tick labels can be numbers or plain text. If the labels are numbers, they could be displayed at uniform intervals (the numbers are treated as normal text) or depending on its x-coodinate value. You can also set limits (maximum and minimum) for the x axis, but only if the tick labels are numeric.

[1] Limitation: Some printers can have problems if the PostScript file is too complex (i.e. too many points/lines appear in the picture).

Y axis
: Y coordinate axis. You can set limits (maximum and minimum) for the y axis. The y axis is drawn at the right margin of the bar chart graph.The y axis consists of the axis line, ticks and tick labels. The tick labels are numeric values determined from the data and are drawn at uniform intervals.

Bar chart graph
: This is the plotting area, placed in the center of the window and surrounded by the axes, the axis titles and the legend (if any). The range of the axes controls what region of the data is plotted. By default, the minimum and maximum limits are determined from the data, but you can set them (as mentioned before). Data points outside the minimum and maximum value of the axes are not plotted.

Legend
: The legend displays the name and symbol of each bar. The legend is placed in the right margin of the Bar chart graph.

Footer text
: Text displayed at the lower part of the window. If text is '' no header text will be displayed.

Quit button
: Button placed below the footer text. Click it to close the window.

All of them are arranged in a window. However you can, for example, show a bar chart window without legend or header text. Other configuration options will be explained later.

In addition to the window appearance there is another important issue about the bar chart window, namely its behaviour in response to user actions. The association user actions to response is called *bindings*. The main bindings currently specified are the following:

Default bindings
: Those are well known by most users. They are related to the frame displayed around the window. As you know, you can interactively move, resize, close, iconify, deiconify, send to another desktop etc. a window.

Bindings related to bar chart graph and its legend
: Clicking the left mouse key over a legend element, the corresponding bar turns out into red. After clicking again, the bar toggles to its original look. In addition, you can do zoom-in by pressing the left mouse key over the bar chart graph and dragging to select an area. To zoom out simply press the right mouse button.

  When the pointer passes over the plotting area the cross hairs are drawn. The cross hairs consists of two intersecting lines (one vertical and one horizontal). Besides, if the pointer is over a legend element, its background changes.

Bindings related to buttons
: There are two buttons in the main widget. Clicking the mouse on the Save button a "Save as" dialog box is popped up. The user can select a file to save the graph. If the user choose a file that already exists, the dialog box prompts the user for confirmation on whether the existing file should be overwritten or not. Furthermore, you can close the widget by clicking on the Quit button.

  When the pointer passes over a button the button color changes.

The predicates that belong to this group are those whose names begin with **barchart** and **genmultibar**. If you take a look at the predicate names that pertain to this group, you will notice that they are not self-explanatory. It would have been better to name the predicates in a way that allows the user to identify the predicate features by its name, but it would bring about very long names (i.e barchart_WithoutLegend_BarsAtUniformIntervals_RandomBarsColors). For this reason I decided to simply add a number after barchart to name them.

167.2 Line graphs

It is frequently the case that several datasets need to be displayed on the same plot. If so, you may wish to distinguish the points in different datasets by joining them by lines of different color, or by plotting with symbols of different types. This set of predicates allows the programmer to represent two-dimensional data (X-Y coordinates). Each dataset contains x and y vectors containing the coordinates of the data. You can configure the appearance of the points and the lines which the points are connected with. The configurable line graph components are:

line graph
: This is the plotting area, placed in the center of the window and surrounded by the axes, the axes titles and the legend (if any). The range of the axes controls what region of the data is plotted. By default, the minimum and maximum limits are determined from the data, but you can set them. Data points outside the minimum and maximum value of the axes are not plotted. You can specify how connecting line segments joining successive datapoints are drawn by setting the `Smooth` argument. Smooth can be either linear, step, natural and quadratic. Furthermore, you can select the appearance of the points and lines.

Legend
: The legend displays the name and symbol of each line. The legend is placed in the right margin of the graph.

The elements header, footer, quit and save buttons, the titles and the axes are quite similar to those in barchart graphs, except in that the tick labels will be numbers. All of them are arranged in a window by the geometry manager. However you can, as we mentioned in the above paragraphs, show a line graph window without any titles or footer text. Other configuration options will be explained later in this section or in the corresponding modules.

Related to the behaviour of the widgets in response to user actions (bindings) we will remark the following features:

Bindings related to line graph and its legend
: Clicking the left mouse key over a legend element, the corresponding line turns out into blue. Repeating the action reverts the line to its original color. Moreover, you can do zoom-in by clicking the left mouse key over the bar chart graph and dragging a rectangle defining the area you want to zoom in. To zoom out simply press the right mouse button.

  When the pointer passes over the plotting area the cross hairs are drawn. The cross hairs consists of two intersecting lines (one vertical and one horizontal). Besides, if the pointer is over a legend element, its background changes.

Other bindings
: The default bindings and the bindings related to the save and quit buttons are similar to those in the bar chart graphs.

The predicates that belong to this group are those whose names begin with **graph_**.

167.3 Scatter graphs

The challenge of this section is to introduce some general aspects about the scatter graph predicates group. By invoking the scatter graph predicates the user can represent two-dimensional point datasets. Often you need to display one or several point datasets on the same plot. If so, you may wish to distinguish the points that pertain to different datasets by using plotting symbols of different types, or by displaying them in different colors. This set of predicates allows you to represent two-dimensional data (X-Y coordinates). Each dataset contains x and y vectors containing the coordinates of the data. You can configure the appearance of the points. The configurable scatter graph components are:

scatter graph
: This is the plotting area, placed in the center of the window and surrounded by the axes, the axes titles and the legend (if any). The range of the axes controls what region of the data is plotted. By default, the minimum and maximum limits are determined from the data, but you can set them (as we mentioned before). Data points outside the minimum and maximum value of the axes are not plotted. The user can select the appearance of the points.

Legend
: The legend displays the name and symbol of each point dataset. The legend is drawn in the right margin of the graph.

The elements header, footer, quit and save buttons, the titles and the axes are similar to those in barchart graphs except for that, as in line graphs, the tick labels will be numbers. All of them are arranged in a window by the geometry manager. However you can, for example, show a scatter graph window without titles or footer text, as we mentioned before. Other configuration options will be explained later, in the corresponding modules.

Related to the behaviour of the widgets in response to user actions (bindings) the following features are:

Bindings related to scatter graph and its legend
: Clicking the left mouse key over a legend element, the points which belong to the corresponding dataset turn out into blue. Repeating the action toggles the point dataset to its original color. Moreover, you can do zoom-in by clicking the left mouse key over the bar chart graph and dragging a rectangle defining the area you want to zoom-in on. To do zoom-out simply press the right mouse button.

  When the pointer passes over the plotting area the cross hairs are drawn. The cross hairs consists of two intersecting lines (one vertical and one horizontal). Besides, if the pointer is over a legend element, its background changes.

Other bindings
: The default bindings and the bindings related to the save and quit buttons are similar to those in the bar chart graphs.

The predicates that belong to this group are those whose names began with **scattergraph_**.

167.4 Tables

The purpose of this section is to allow the user to display results in a table. A table is a regular structure in which:

- Every row has the same number of columns, or
- Every column has the same number of rows.

The widget configurable components are as follows:

Title
: Title of the widget, it is displayed centered at the top of the canvas. If text is '' no title will be displayed.

Header text
: Left centered text displayed bellow the title. If text is '' no header text will be displayed.

Table
: Is placed in the center of the window. The table is composed by cells ordered in rows and columns. The cell values can be either any kind of text or numbers and they can be empty as well (see the type definition in the corresponding chapter module). A table is a list of lists. Each sublist is a row, so every sublist in the table must contain the same number of alements.

Footer text
: Left centered text displayed at the lower part of the window. If text is '' no header text will be displayed.

Quit button
: Button placed below the footer text. You can click it to close the window.

If the arguments are not in a correct format an exception will be thrown. Moreover, these widgets have the default bindings and the binding related to the quit button:

The set of predicates that belongs to this group are those which names begin with **table_widget**.

167.5 Overview of widgets

Although you don't have to worry about how to arrange the widgets, here is an overview of how Tcl-tk, the underlying graphical system currently used by chartlib, performs this task. Quoting from the book *Tcl and Tk toolkit*, John K. Ousterhout.

The X Window System provides many facilities for manipulating windows in displays. The root window may have any number of child windows, each of wich is called a top-level window. Top-level windows may have children of their own, wich may have also children, and so on. The descendants of top-level windows are called internal windows. Internal windows are usedfor individual controls such as buttons, text entries, and for grouping controls together. An X-application tipically manages several top-level windows. Tk uses X to implement a set of controls with the Motif look and feel. These controls are called widgets. Each widget is implemented using one X window, and the terms "window" and "widget" will be used interchangeably in this document. As with windows, widgets are nested in hierarchical structures. In this library top-level widgets (nonleaf or main) are just containers for organizing and arranging the leaf widgets (components). Thereby, the barchart widget is a top-level window wich contains some widget components.

Probably the most painstaking aspect of building a graphical application is getting the placement and size of the widgets just right. It usually takes many iterations to align widgets and adjust their spacing. That's because managing the geometry of widgets is simply not a packing problem, but also graphical design problem. Attributes such as alignment, symmetry, and balance are more important than minimizing the amount of space used for packing. Tk is similar to other X toolkits in that it does not allow widgets to determine their own geometries. A widget will not even appeared unless it is managed by a geometry manager. This separation of geometry management from internal widget behaviour allows multiple geometry managers to exist simultaneously and permits any widget to be used with any geometry manager. A geometry manager's job is to arrange one or more *slave* widgets relative to a *master* widgets. There are some geometry managers in Tk such as pack, place and canvas widget. We will use another one call table.

The table geometry manager arranges widgets in a table. It's easy to align widgets (horizontally and vertically) or to create empty space to balance the arrangement of the widgets. Widgets (called slaves in the Tk parlance) are arranged inside a containing widget (called the master). Widgets are positioned at row,column locations and may span any number of rows or columns. More than one widget can occupy a single location. The placement of widget windows determines both the size and arrangement of the table. The table queries the requested size of each widget. The requested size of a widget is the natural size of the widget (before the widget is shrunk or expanded). The height of each row and the width of each column is the largest widget spanning that row or column. The size of the table is in turn the sum of the row and column sizes. This is the table's normal size. The total number of rows and columns in a table is determined from the indices specified. The table grows dynamically as windows are added at larger indices.

167.6 Usage and interface (chartlib)

- **Library usage:**
  `:- use_module(library(chartlib)).`
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/genbar2`, `chartlib/genbar3`, `chartlib/genbar4`, `chartlib/genmultibar`, `chartlib/table_widget1`, `chartlib/table_widget2`, `chartlib/table_widget3`, `chartlib/table_widget4`, `chartlib/gengraph1`, `chartlib/gengraph2`, `chartlib/chartlib_errhandle`.

167.7 Documentation on exports (chartlib)

barchart1/7: (UNDOC_REEXPORT)
Imported from `genbar1` (see the corresponding documentation for details).

barchart1/9: (UNDOC_REEXPORT)
Imported from `genbar1` (see the corresponding documentation for details).

percentbarchart1/7: (UNDOC_REEXPORT)
Imported from `genbar1` (see the corresponding documentation for details).

barchart2/7: (UNDOC_REEXPORT)
Imported from `genbar2` (see the corresponding documentation for details).

barchart2/11: (UNDOC_REEXPORT)
Imported from `genbar2` (see the corresponding documentation for details).

percentbarchart2/7: (UNDOC_REEXPORT)
Imported from `genbar2` (see the corresponding documentation for details).

barchart3/7: (UNDOC_REEXPORT)
Imported from `genbar3` (see the corresponding documentation for details).

barchart3/9: (UNDOC_REEXPORT)
Imported from `genbar3` (see the corresponding documentation for details).

percentbarchart3/7: (UNDOC_REEXPORT)
Imported from `genbar3` (see the corresponding documentation for details).

barchart4/7: (UNDOC_REEXPORT)
Imported from `genbar4` (see the corresponding documentation for details).

barchart4/11: (UNDOC_REEXPORT)
Imported from `genbar4` (see the corresponding documentation for details).

percentbarchart4/7: (UNDOC_REEXPORT)
Imported from `genbar4` (see the corresponding documentation for details).

multibarchart/8: (UNDOC_REEXPORT)
Imported from `genmultibar` (see the corresponding documentation for details).

multibarchart/10: (UNDOC_REEXPORT)
Imported from `genmultibar` (see the corresponding documentation for details).

tablewidget1/4: (UNDOC_REEXPORT)
Imported from `table_widget1` (see the corresponding documentation for details).

tablewidget1/5: (UNDOC_REEXPORT)
Imported from `table_widget1` (see the corresponding documentation for details).

tablewidget2/4: (UNDOC_REEXPORT)
Imported from `table_widget2` (see the corresponding documentation for details).

tablewidget2/5: (UNDOC_REEXPORT)
Imported from `table_widget2` (see the corresponding documentation for details).

tablewidget3/4: (UNDOC_REEXPORT)
Imported from `table_widget3` (see the corresponding documentation for details).

tablewidget3/5: (UNDOC_REEXPORT)
Imported from `table_widget3` (see the corresponding documentation for details).

tablewidget4/4: (UNDOC_REEXPORT)
Imported from `table_widget4` (see the corresponding documentation for details).

tablewidget4/5: (UNDOC_REEXPORT)
Imported from `table_widget4` (see the corresponding documentation for details).

graph_b1/9: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_b1/13: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_w1/9: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_w1/13: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_b1/8: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_b1/12: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_w1/8: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

scattergraph_w1/12: (UNDOC_REEXPORT)
Imported from `gengraph1` (see the corresponding documentation for details).

graph_b2/9: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

graph_b2/13: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

graph_w2/9: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

graph_w2/13: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_b2/8: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_b2/12: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_w2/8: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

scattergraph_w2/12: (UNDOC_REEXPORT)
Imported from `gengraph2` (see the corresponding documentation for details).

chartlib_text_error_protect/1: (UNDOC_REEXPORT)
Imported from `chartlib_errhandle` (see the corresponding documentation for details).

chartlib_visual_error_protect/1: (UNDOC_REEXPORT)
Imported from `chartlib_errhandle` (see the corresponding documentation for details).

168 Low level Interface between Prolog and blt

This module exports some predicates to interact with Tcl-tk, particularly with the bltwish program. Bltwish is a windowing shell consisting of the Tcl command languaje, the Tk toolkit plus the additional commands that comes with the BLT library and a main program that reads commands. It creates a main window and then processes Tcl commands.

168.1 Usage and interface (`bltclass`)

- **Library usage:**
  `:- use_module(library(bltclass)).`
- **Exports:**
  - *Predicates:*
    `new_interp/1`, `tcltk_raw_code/2`, `interp_file/2`.
  - *Regular Types:*
    `bltwish_interp/1`.
- **Other modules used:**
  - *System library modules:*
    `sockets/sockets`, `system`, `write`, `read`, `strings`, `format`, `terms`.

168.2 Documentation on exports (`bltclass`)

new_interp/1: PREDICATE

`new_interp(Interp)`

Creates a bltwish interprter and returns a socket. The socket allows the comunication between Prolog and Tcl-tk. Thus, bltwish receives the commands through the socket.

tcltk_raw_code/2: PREDICATE

`tcltk_raw_code(Command_Line,Interp)`

Sends a command line to the interpreter. Tcl-tk parses and executes it.

bltwish_interp/1: REGTYPE

`bltwish_interp(Interp)`

This type defines a bltwish interpreter. In fact, the bltwish interpreter receives the commands through the socket created.

```
bltwish_interp(Interp) :-
        stream(Interp).
```

interp_file/2: PREDICATE

`interp_file(File,Interp)`

Sends the script file (File) to the interpreter through the socket. A script file is a file that contains commands that Tcl-tk can execute.

169 chartlib_errhandle (library)

This module is an error handler. If the format of the arguments is not correct in a call to a chartlib predicate an exception will be thrown . You can wrap the chartlib predicates with the predicates exported by this module to handle automatically the errors if any.

169.1 Usage and interface (chartlib_errhandle)

- **Library usage:**
  `:- use_module(library(chartlib_errhandle)).`
- **Exports:**
  - *Predicates:*
    `chartlib_text_error_protect/1`, `chartlib_visual_error_protect/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/bltclass`, `chartlib/install_utils`.

169.2 Documentation on exports (chartlib_errhandle)

chartlib_text_error_protect/1: PREDICATE

`chartlib_text_error_protect(G)`

This predicate catches the thrown exception and sends it to the appropiate handler. The handler will show the error message in the standard output.

Meta-predicate with arguments: `chartlib_text_error_protect(goal)`.

chartlib_visual_error_protect/1: PREDICATE

`chartlib_visual_error_protect(G)`

This predicate catches the thrown exception and sends it to the appropiate handler. The handler will pop up a message box.

Meta-predicate with arguments: `chartlib_visual_error_protect(goal)`.

169.3 Documentation on internals (chartlib_errhandle)

handler_type/1: REGTYPE

`handler_type(X)`

The library chartlib includes two error handlers already programmed.

```
handler_type(text).
handler_type(visual).
```

error_message/2: PREDICATE

`error_message(ErrorCode,ErrorMessage)`

Binds the error code with its corresponding text message.

error_file/2: PREDICATE

`error_file(ErrorCode,ErrorFile)`

Binds the error code with its corresponding script error file.

170 Color and Pattern Library

This module contains predicates to access and check conformance to the available colors and patterns.

170.1 Usage and interface (color_pattern)

- **Library usage:**
  `:- use_module(library(color_pattern)).`
- **Exports:**
  - *Predicates:*
    `color/2`, `pattern/2`, `random_color/1`, `random_lightcolor/1`, `random_darkcolor/1`, `random_pattern/1`.
  - *Regular Types:*
    `color/1`, `pattern/1`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `random/random`.

170.2 Documentation on exports (color_pattern)

color/1: REGTYPE

```
color(Color)

    color('GreenYellow').
    color('Yellow').
    color('White').
    color('Wheat').
    color('BlueViolet').
    color('Violet').
    color('MediumTurquoise').
    color('DarkTurquoise').
    color('Turquoise').
    color('Thistle').
    color('Tan').
    color('Sienna').
    color('Salmon').
    color('VioletRed').
    color('OrangeRed').
    color('MediumVioletRed').
    color('IndianRed').
    color('Red').
    color('Plum').
    color('Pink').
    color('MediumOrchid').
    color('DarkOrchid').
    color('Orchid').
```

```
color('Orange').
color('Maroon').
color('Magenta').
color('Khaki').
color('Grey').
color('LightGray').
color('DimGray').
color('DarkSlateGray').
color('YellowGreen').
color('SpringGreen').
color('SeaGreen').
color('PaleGreen').
color('MediumSpringGreen').
color('MediumSeaGreen').
color('LimeGreen').
color('ForestGreen').
color('DarkOliveGreen').
color('DarkGreen').
color('Green').
color('Goldenrod').
color('Gold').
color('Brown').
color('Firebrick').
color('Cyan').
color('Coral').
color('SteelBlue').
color('SlateBlue').
color('SkyBlue').
color('Navy').
color('MidnightBlue').
color('MediumSlateBlue').
color('MediumBlue').
color('LightSteelBlue').
color('LightBlue').
color('DarkSlateBlue').
color('CornflowerBlue').
color('CadetBlue').
color('Blue').
color('Black').
color('MediumAquamarine').
color('Aquamarine').
```

Defines available colors for elements such as points, lines or bars.

color/2: PREDICATE

Usage: `color(C1,C2)`

- *Description:* Test whether the color `C1` is a valid color or not. If `C1` is a variable the predicate will choose a valid color randomly. If `C1` is a ground term that is not a valid color an exception (error9) will be thrown
- *The following properties should hold at call time:*

  `color_pattern:color(C1)` (`color_pattern:color/1`)

– *The following properties should hold upon exit:*
`color_pattern:color(C2)` (`color_pattern:color/1`)

pattern/1: REGTYPE

`pattern(Pattern)`

```
pattern(pattern1).
pattern(pattern2).
pattern(pattern3).
pattern(pattern4).
pattern(pattern5).
pattern(pattern6).
pattern(pattern7).
pattern(pattern8).
pattern(pattern9).
```

Defines valid patterns used in the stipple style bar attribute.

pattern/2: PREDICATE

Usage: `pattern(P1,P2)`

– *Description:* Test whether the pattern `P1` is a valid pattern or not. If `P1` is a variable the predicate will choose a valid pattern randomly. If `P1` is a ground term that is not a valid pattern an exception (error10) will be thrown.
– *The following properties should hold at call time:*
`color_pattern:pattern(P1)` (`color_pattern:pattern/1`)
– *The following properties should hold upon exit:*
`color_pattern:pattern(P2)` (`color_pattern:pattern/1`)

random_color/1: PREDICATE

`random_color(Color)`

This predicate choose a valid color among the availables randomly.

random_lightcolor/1: PREDICATE

`random_lightcolor(Color)`

This predicate choose a valid light color among the availables randomly.

random_darkcolor/1: PREDICATE

`random_darkcolor(Color)`

This predicate choose a valid dark color among the availables randomly.

random_pattern/1: PREDICATE

`random_pattern(Pattern)`

This predicate choose a valid pattern among the availables randomly.

171 genbar1 (library)

This module defines predicates to show barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window. They all share the following features:

- No numeric values for the `x` axis are needed because they will be interpreted as labels. See `xbarelement1/1` definition type.
- The bars will be displayed at uniform intervals.
- The user can either select the appearance of the bars (background color, foreground color and stipple style) or not. See the `xbarelement1` type definition. Thus, the user can call each predicate in two ways.
- The bar chart has a legend. One entry (symbol and label) per bar.
- If you don't want to display text in the elements header, barchart title, x axis title, y axis title or footer, simply type `''` as the value of the argument.
- The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` do not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

Particular features will be pointed out in the corresponding predicate.

171.1 Usage and interface (genbar1)

- **Library usage:**
  `:- use_module(library(genbar1)).`
- **Exports:**
  - *Predicates:*
    `barchart1/7`, `barchart1/9`, `percentbarchart1/7`.
  - *Regular Types:*
    `yelement/1`, `axis_limit/1`, `header/1`, `title/1`, `footer/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/bltclass`, `chartlib/test_format`, `chartlib/color_pattern`, `chartlib/install_utils`, `lists`, `random/random`.

171.2 Documentation on exports (genbar1)

barchart1/7: PREDICATE

`barchart1(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

The `y` axis range is determined from the limits of the data. Two examples are given to demonstrate clearly how to call the predicates. In the first example the user sets the bar appearance, in the second one the appearance features will be chosen by the system and the colors that have been assigned to the variables Color1, Color2 and Pattern will be shown also.

Example 1:

```
barchart1('This is the header text',
  'Barchart title',
  'xaxistitle',
  [ ['bar1','legend_element1','Blue','Yellow','pattern1'],
          ['bar2','legend_element2','Plum','SeaGreen','pattern2'],
          ['bar3','legend_element3','Turquoise','Yellow','pattern5'] ],
  'yaxixtitle',
  [20,10,59],
  'footer').
```

Example 2:

```
barchart1('This is the header text',
  'Barchart title',
  'xaxistitle',
  [ ['element1','legend_element1',Color1,Color2,Pattern],
           ['element2','legend_element2'],
           ['element3','legend_element3'] ],
  'yaxixtitle',
  [20,10,59],
  'footer').
```

barchart1/9: PREDICATE

`barchart1(Header,BTitle,XTitle,XVector,YTitle,YVector,YMax,YMin,Footer)`

You can set the minimum and maximum limits of the `y` axis. Data outside the limits will not be plotted. Each limit, as you can check by looking at the `axis_limit/1` definition, is a number. If the argument is a variable the limit will be calculated from the data (i.e., if `YMax` value is YValueMax the maximum y axis limit will calculated using the largest data value).

Example:

```
barchart1('This is the header text',
  'Barchart title',
  'xaxistitle',
  [ ['element1','e1','Blue','Yellow','pattern1'],
      ['element2','e2','Turquoise','Plum','pattern5'],
      ['element3','e3','Turquoise','Green','pattern5'] ],
  'yaxixtitle',
  [20,10,59],
  70,
  -,
  'footer').
```

percentbarchart1/7: PREDICATE

`percentbarchart1(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The `x` axis limits are automatically worked out.

Example:

```
percentbarchart1('This is a special barchart to represent percentages',
  'Barchart with legend',
```

```
'My xaxistitle',
[ [1,'bar1','Blue','Yellow','pattern1'],
     [8,'bar2','MediumTurquoise','Plum','pattern5'] ],
'My yaxixtitle',
[80,10],
'This is the footer text').
```

yelement/1: REGTYPE

```
yelement(Y) :-
        number(Y).
```

Y is the bar lenght, so it must be a numeric value.

Both Prolog and Tcl-Tk support integers and floats. Integers are usually specified in decimal, but if the first character is 0 the number is read in octal (base 8), and if the first two characters are 0x, the number is read in hexadecimal (base16). Float numbers may be specified using most of the forms defined for ANSI C, including the following examples:

- 9.56
- 5.88e-2
- 5.1E2

Note: Be careful when using floats. While 8. or 7.e4 is interpreted by Tcl-tk as 8.0 and 7.0e4, Prolog will not read them as float numbers. Example:

```
?- number(8.e+5).
{SYNTAX ERROR: (lns 130-130) , or ) expected in arguments
number ( 8
** here **
. e + 5 ) .
}

no
?- number(8.).
{SYNTAX ERROR: (lns 138-138) , or ) expected in arguments
number ( 8
** here **
. ) .
}

no

?- number(8.0e+5).

yes
?- number(8.0).

yes
```

Precision: Tcl-tk internally represents integers with the C type `int`, which provides at least 32 bits of precision on most machines. Since Prolog integers can (in some implementations) exceed 32 bits but the precision in Tcl-tk depends on the machine, it is up to the progammer to ensure that the values fit into the maximum precision of the machine for

integers. Real numbers are represented with the C type `double`, which is usually represented with 64-bit values (about 15 decimal digits of precision) using the IEEE Floating Point Standard.

Conversion: If the list is composed by integers and floats, Tcl-tk will convert integers to floats.

axis_limit/1: REGTYPE

```
axis_limit(X) :-
        number(X).
axis_limit(_1).
```

This type is defined in order to set the minimum and maximum limits of the axes. Data outside the limits will not be plotted. Each limit, is a number or a variable. If the argument is not a number the limit will be calculated from the data (i.e., if YMax value is `Var` the maximum y axis limit will be calculated using the largest data value).

header/1: REGTYPE

Usage: `header(X)`

- *Description:* `X` is a text (an atom) describing the header of the graph.

title/1: REGTYPE

Usage: `title(X)`

- *Description:* `X` is a text (an atom) to be used as label, usually not very long.

footer/1: REGTYPE

Usage: `footer(X)`

- *Description:* `X` is a text (an atom) describing the footer of the graph.

171.3 Documentation on internals (genbar1)

xbarelement1/1: REGTYPE

```
xbarelement1([XValue,LegendElement]) :-
        atomic(XValue),
        atomic(LegendElement).
xbarelement1([XValue,LegendElement,ForegColor,BackgColor,SPattern]) :-
        atomic(XValue),
        atomic(LegendElement),
        color(ForegColor),
        color(BackgColor),
        pattern(SPattern).
```

Defines the attributes of the bar.

`XValue` bar label. Although `XValue` values may be numbers, the will be treated as labels. Different elements with the same label will produce different bars.

`LegendElement`
: Legend element name. It may be a number or an atom and equal or different to the XValue. Every `LegendElement` value of the list must be unique.

`ForegColor`
: It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
: It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern`
: It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

172 genbar2 (library)

This module defines predicates which show barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window. They all share the following features:

- Numeric values for the x axis are needed, otherwise it does not work properly. See `xbarelement2/1` definition type.
- The bar position is proportional to the x-coordinate value.
- The user can either select the appearance of the bars (background color, foreground color and stipple style) or not. See the `xbarelement2/1` type definition. Thus, the user can call each predicate in two ways.
- The bar chart has a legend and one entry (symbol and label) per bar.
- If you do not want to display text in the elements header, barchart title, x axis title, y axis title or footer, simply type `''` as the value of the argument.
- The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contain elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` does not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

Particular features will be pointed out in the corresponding predicate.

172.1 Usage and interface (genbar2)

- **Library usage:**
  `:- use_module(library(genbar2)).`
- **Exports:**
  - *Predicates:*
    `barchart2/7`, `barchart2/11`, `percentbarchart2/7`.
  - *Regular Types:*
    `xbarelement2/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

172.2 Documentation on exports (genbar2)

barchart2/7: PREDICATE

`barchart2(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

The maximum and minimum limits for axes are determined from the data.

Example:

```
barchart2('This is the header text',
  'Barchart with legend',
```

```
  'My xaxistitle',
  [ [1,'bar1','Blue','Yellow','pattern1'],
       [2,'bar2','MediumTurquoise','Plum','pattern5'] ],
  'My yaxixtitle',
  [20,10],
  'This is the footer text').
```

barchart2/11: PREDICATE

`barchart2(Header,BT,XT,XVector,XMax,XMin,YT,YVector,YMax,YMin,Footer)`

You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted. Each limit, as you can check looking at the `axis_limit/1` definition, is a number. If the argument is a variable the limit will be calculated from the data (i.e., if `YMax` value is YValueMax the maximum y axis limit will calculated using the largest data value).

Example:

```
barchart2('This is the header text',
  'Barchart with legend',
  'My xaxistitle',
  [ [1,'bar1',Color1,Color2,Pattern1],
        [2,'bar2',Color3,Color4,Pattern2] ],
  10,
  -10,
  'My yaxixtitle',
  [20,10],
  100,
  -10,
  'The limits for the axes are set by the user').
```

percentbarchart2/7: PREDICATE

`percentbarchart2(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The x axis limits are autoarrange.

Example:

```
percentbarchart2('This is a special barchart to represent percentages',
  'Barchart with legend',
  'My xaxistitle',
  [ [1,'bar1','Blue','Yellow','pattern1'],
         [2,'bar2','MediumTurquoise','Plum','pattern5'] ],
  'My yaxixtitle',
  [80,10],
  'This is the footer text').
```

xbarelement2/1: REGTYPE

```
xbarelement2([XValue,LegendElement]) :-
        number(XValue),
        atomic(LegendElement).
xbarelement2([XValue,LegendElement,ForegColor,BackgColor,SPattern]) :-
```

```
number(XValue),
atomic(LegendElement),
color(ForegColor),
color(BackgColor),
pattern(SPattern).
```

Defines the attributes of the bar.

`XValue` x-coordinate position of the bar. Different elements with the same abscissas will produce overlapped bars.

`LegendElement`
Element legend name. It may be a number or an atom and equal or different to the XValue. Every `LegendElement` value of the list must be unique.

`ForegColor`
Is the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
Is the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern` Is the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

173 genbar3 (library)

This module defines predicates which depict barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window and are similar to those exported in the genbar1 module except in that these defined in this module do not display a legend. Thus, not all the argument types are equal.

The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contain elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` do not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

173.1 Usage and interface (genbar3)

- **Library usage:**
  `:- use_module(library(genbar3)).`
- **Exports:**
  - *Predicates:*
    `barchart3/7`, `barchart3/9`, `percentbarchart3/7`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

173.2 Documentation on exports (genbar3)

barchart3/7: PREDICATE

`barchart3(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

As we mentioned in the above paragraph, this predicate is comparable to `barchart1/8` except in the `XVector` argument type.

Example:

```
barchart3('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [['bar1'],['bar2']],
  'My yaxixtitle',
  [20,10],
  'This is the footer text').
```

barchart3/9: PREDICATE

`barchart3(Header,BTitle,XTitle,XVector,YTitle,YVector,YMax,YMin,Footer)`

As we mentioned, this predicate is quite similar to the `barchart1/10` except in the `XVector` argument type, because the yielded bar chart lacks of legend.

Example:

```
barchart3('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [['bar1'],['bar2']],
  'My yaxixtitle',
  30,
  5,
  [20,10],
  'This is the footer text').
```

percentbarchart3/7: PREDICATE

`percentbarchart3(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The x axis limits are autoarrange.

Example:

```
percentbarchart3('This is a special barchart to represent percentages',
          'Barchart without legend',
          'My xaxistitle',
          [ ['pr1','Blue','Yellow','pattern1'],
            ['pr2','MediumTurquoise','Plum','pattern5'] ],
          'My yaxixtitle',
          [80,10],
          'This is the footer text').
```

173.3 Documentation on internals (genbar3)

xbarelement3/1: REGTYPE

```
xbarelement3([XValue]) :-
        atomic(XValue).
xbarelement3([XValue,ForegColor,BackgColor,StipplePattern]) :-
        atomic(XValue),
        color(ForegColor),
        color(BackgColor),
        pattern(StipplePattern).
```

Defines the attributes of the bar.

`XValue` bar label. Although `XValue` values may be numbers, the will be treated as labels. Different elements with the same label will produce different bars.

`ForegColor`
It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern` It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

174 genbar4 (library)

This module defines predicates which depict barchart widgets. The three predicates exported by this module plot two-variable data as regular bars in a window and are similar to those exported in genbar2 module except in that those defined in this module doesn't display a legend. Thus, the user does not have to define legend element names.

The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error1` or `error3` will be thrown, depending on the error type. `error1` means that `XVector` and `YVector` do not contain the same number of elements and `error3` indicates that not all the `XVector` elements contain a correct number of attributes .

174.1 Usage and interface (genbar4)

- **Library usage:**
  `:- use_module(library(genbar4)).`
- **Exports:**
  - *Predicates:*
    `barchart4/7`, `barchart4/11`, `percentbarchart4/7`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

174.2 Documentation on exports (genbar4)

barchart4/7: PREDICATE

`barchart4(Header,BarchartTitle,XTitle,XVector,YTitle,YVector,Footer)`

As we mentioned in the above paragraph, this predicate is comparable to `barchart2/8` except in the `XVector` argument type.

Example:

```
barchart4('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [[2],[5],[6]],
  'My yaxixtitle',
  [20,10,59],
  'Numeric values in the xaxis').
```

barchart4/11: PREDICATE

`barchart4(Hder,BT,XT,XVector,XMax,XMin,YT,YVector,YMax,YMin,Fter)`

As we stated before, this predicate is quite similar to `barchart2/10` except in the following aspects:

- The `XVector` argument type, because the yielded bar chart lacks the legend.

- The user can set limits for both x axis and y axis.

Example:

```
barchart4('This is the header text, you can write a graph description',
  'Barchart without legend',
  'My xaxistitle',
  [[2,'Blue','Yellow','pattern1'],
       [20,'MediumTurquoise','Plum','pattern5'],
       [30,'MediumTurquoise','Green','pattern5']],
  50,
  -10,
  'My yaxixtitle',
  [20,10,59],
  100,
  -10,
  'Numeric values in the xaxis').
```

percentbarchart4/7: PREDICATE

`percentbarchart4(Header,BTitle,XTitle,XVector,YTitle,YVector,Footer)`

The y axis maximum coordinate value is 100. The x axis limits are automatically worked out. This predicate is useful when the bar height represents percentages.

Example:

```
percentbarchart4('This is the header text',
  'Barchart without legend',
  'My xaxistitle',
  [[2,'Blue','Yellow','pattern1'],[5,'Yellow','Plum','pattern5'],
       [6,'MediumTurquoise','Green','pattern5']],
  'My yaxixtitle',
  [20,10,59],
  'Numeric values in the xaxis').
```

174.3 Documentation on internals (genbar4)

xbarelement4/1: REGTYPE

Defines the attributes of the bar.

`XValue` x-coordinate position of the bar. Different elements with the same abscissas will produce overlapped bars.

`ForegColor`
It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern` It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

175 gengraph1 (library)

This module defines predicates which depict line graph and scatter graph widgets. All eigth predicates exported by this module plot two-variable data. Each point is defined by its X-Y coordinate values. A dataset is defined by two lists xvector and yvector, which contain the points coordinates. As you might guess, the values placed in the the same position in both lists are the coordinates of a point. They both share the following features:

- Numeric values for vector elements are needed. We'll use two vectors to represent the X-Y coordinates of each set of plotted data, but in this case every dataset shares the X-vector, i.e., x-coordinate of points with the same index[1] in different datasets is the same. Thus, the numbers of points in each yvector must be equal to the number of points in the xvector.
- The active element color is navyblue, which means that when you select a legend element, the corresponding line or point dataset turns into navyblue.
- The user can either select the appearance of the lines and/or points of each dataset or not. If not, the system will choose the colors for the lines and the points among the available ones in accordance with the plot background color and it will also set the points size and symbol to the default. If the plot background color is black, the system will choose a lighter color, and the system will select a darker color when the plot background color is white. Thus, the user can define the appearanse attributes of each dataset in four different ways. Take a look at the `attributes/1` type definition and see the examples to understand it clearly.
- The graph has a legend and one entry (symbol and label) per dataset.
- If you do not want to display text in the element header, barchart title, xaxis title, yaxis title or footer, simply give `''` as the value of the argument.
- The predicates check whether the format of the arguments is correct as well. The testing process involves some verifications. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error4` will be thrown.

The names of the line graph predicates begin with **graph_** and those corresponding to the scatter graph group begin with **scattergraph_**.

175.1 Usage and interface (gengraph1)

- **Library usage:**
  `:- use_module(library(gengraph1)).`
- **Exports:**
  - *Predicates:*
    `graph_b1/9`, `graph_b1/13`, `graph_w1/9`, `graph_w1/13`, `scattergraph_b1/8`, `scattergraph_b1/12`, `scattergraph_w1/8`, `scattergraph_w1/12`.
  - *Regular Types:*
    `vector/1`, `smooth/1`, `attributes/1`, `symbol/1`, `size/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/bltclass`, `chartlib/genbar1`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

[1] It should be pointed out that I am refering to an index as the position of an element in a list.

175.2 Documentation on exports (gengraph1)

graph_b1/9: PREDICATE

`graph_b1(Header,GTitle,XTitle,XVector,YTitle,YVectors,LAtts,Footer,Smooth)`

Besides the features mentioned at the begining of the chapter, the displayed graph generated when calling this predicate has the following distinguishing characteristics:

- The plotting area background color is black.
- The cross hairs color is white.
- The axes limits are determined from the data.

Example:

```
graph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  'yaxixtitle',
  [ [10,35,40],[25,50,60] ],
  [ ['element1','Blue','Yellow','plus',6],['element2',Outline,Color] ],
  'footer',
  'linear').
```

graph_b1/13: PREDICATE

`graph_b1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

The particular features related to this predicate are described below:

- The plotting area background color is black.
- The cross hairs color is white.
- You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted.

Example:

```
graph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['line1','circle',4],['line2',OutlineColor,Color]],
  'footer',
  'step').
```

graph_w1/9: PREDICATE

`graph_w1(Header,GTitle,XTitle,XVector,YTitle,YVectors,LAtts,Footer,Smooth)`

This predicate is quite similar to `graph_b1/9`. The differences lies in the plot background color and in the cross hairs color, which are white and black respectively.

Example:

```
graph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,40,50],
  'yaxixtitle',
  [ [10,35,40,50],[25,20,60,40] ],
  [['line1','Blue','DarkOrchid'],['line2','circle',3]],
  'footer',
  'quadratic').
```

graph_w1/13: PREDICATE

`graph_w1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

This predicate is quite similar to `graph_b1/13`, the differences between them are listed below:

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
graph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  100,
  10,
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  _,
  _,
  [['element1','Blue','Yellow'],['element2','Turquoise','Plum']],
  'footer',
  'quadratic').
```

scattergraph_b1/8: PREDICATE

`scattergraph_b1(Header,GTitle,XTitle,XVector,YTitle,YVectors,PAtts,Footer)`

Apart from the features brought up at the beginning of the chapter, the scatter graph displayed invoking this predicate has the following characteristics:

- The plotting area background color is black.
- The cross hairs color is white.
- The axes limits are determined from the data.

Example:

```
scattergraph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [10,15,20],
```

```
  'yaxixtitle',
  [[10,35,20],[15,11,21]],
  [['element1','Blue','Yellow'],['element2','Turquoise','Plum']],
  'footer').
```

scattergraph_b1/12: PREDICATE

`scattergraph_b1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

The particular features related to this predicate are described below:

- The plotting area background color is black.
- The cross hairs color is white.
- You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted.

Example:

```
scattergraph_b1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['point dataset1','Blue','Yellow'],['point dataset2']],
  'footer').
```

scattergraph_w1/8: PREDICATE

`scattergraph_w1(Header,GT,XT,XVector,YT,YVectors,PAtts,Footer)`

This predicate is quite similar to `scattergraph_b1/8` except in the following:

- The plotting area background color is black.
- The cross hairs color is white.
- If the user does not fix the points colors, they will be chosen among the lighter ones.

Example:

```
scattergraph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  [['e1','Blue','Green'],['e2','MediumVioletRed','Plum']],
  'footer').
```

scattergraph_w1/12: PREDICATE

`scattergraph_w1(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

This predicate is quite similar to `scattergraph1_b1/13`, the differences between them are listed below:

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
scattergraph_w1('This is the header text',
  'Graph_title',
  'xaxistitle',
  [20,10,59],
  150,
  5,
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  _,
  -10,
  [['e1','Blue','Yellow'],['e2','MediumTurquoise','Plum']],
  'footer').
```

vector/1: REGTYPE

```
vector(X) :-
        list(X,number).
```

The type vector defines a list of numbers (integers or floats).

smooth/1: REGTYPE

```
smooth(Smooth)
```

```
smooth(linear).
smooth(cubic).
smooth(quadratic).
smooth(step).
```

Specifies how connecting segments are drawn between data points. If `Smooth` is `linear`, a single line segment is drawn, connecting both data points. When `Smooth` is `step`, two line segments will be drawn, the first line is a horizontal line segment that steps the next X-coordinate and the second one is a vertical line, moving to the next Y-coordinate. Both `cubic` and `quadratic` generate multiple segments between data points. If `cubic`is used, the segments are generated using a cubic spline. If `quadratic`, a quadratic spline is used. The default is linear.

attributes/1: REGTYPE

```
attributes([ElementName]) :-
        atomic(ElementName).
attributes([ElementName,OutLine,Color]) :-
        atomic(ElementName),
        color(OutLine),
        color(Color).
attributes([ElementName,Symbol,Size]) :-
        atomic(ElementName),
        symbol(Symbol),
        size(Size).
```

```
attributes([ElementName,OutLine,Color,Symbol,Size]) :-
        atomic(ElementName),
        color(OutLine),
        color(Color),
        symbol(Symbol),
        size(Size).
```

Each line or point dataset in the graph has its own attributes, which are defined by this type. The name of the dataset, specified in the `ElementName` argument, may be either a number or an atom. The second argument is the color of a thin line around each point in the dataset and the Color argument is the points and lines color. Both `OutLine` and `Color` must be a valid color (see available values in `color/1`), otherwise a random color according to the plot background color will be selected. The `Symbol` must be a valid symbol and the `Size` must be a number. Be careful if you want to especify the `Symbol` and the `Size`, otherwise the predicate will not work as you expect. If you don't select a symbol and a size for a dataset the default values will be square and 1 pixel.

symbol/1: REGTYPE

```
symbol(Symbol)
```

```
symbol(square).
symbol(circle).
symbol(diamond).
symbol(plus).
symbol(cross).
symbol(splus).
symbol(scross).
symbol(triangle).
```

`Symbol` stands for the shape of the points whether in scatter graphs or in line graphs.

size/1: REGTYPE

```
size(Size)
```

```
size(Size) :-
        number(Size).
```

`Size` stands for the size in pixels of the points whether in scatter graphs or in line graphs.

176 gengraph2 (library)

This module defines predicates which show line graph widgets. All eight predicates exported by this module plot two-variable data. Each point is defined by its X-Y coordinate values. Every predicate share the following features:

- A dataset is defined by three lists xvector, yvector and attributes. The arguments named `XVectors` (or `XVs`), `YVectors` (or `YVs`) and `LAtts`[1] contain this information. Those arguments must be lists whose elements are also lists. The first dataset is defined by the firts element of the three lists, the second dataset is defined by the second element of the three lists and so on.
- Numeric values for the vector elements are needed. We will use two vectors to represent the X-Y coordinates of each set of data plotted. In these predicates the vectors can have different number of points. However, the number of elements in xvector and yvector that pertain to a certain dataset must be, obviously, equal.
- The active line color is blue, which means that when you select a legend element, the corresponding line turns into navyblue.
- The user can either select the appearance for the lines and the points or not. See the `attributes/1` type definition. Thus, the user can call each predicate in different ways ways.
- The graph has a legend and one entry (symbol and label) per dataset.
- If you do not want to display text in the elements header, barchart title, xaxis title, yaxis title or footer, simply give `''` as the value of the argument.
- The predicates check whether the format of the arguments is correct as well. The testing process involves some verifications. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error4` will be thrown.

176.1 Usage and interface (gengraph2)

- **Library usage:**
  `:- use_module(library(gengraph2)).`
- **Exports:**
  - *Predicates:*
    `graph_b2/9`, `graph_b2/13`, `graph_w2/9`, `graph_w2/13`, `scattergraph_b2/8`, `scattergraph_b2/12`, `scattergraph_w2/8`, `scattergraph_w2/12`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/gengraph1`, `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `lists`, `random/random`.

176.2 Documentation on exports (gengraph2)

graph_b2/9: PREDICATE

`graph_b2(Header,GTitle,XTitle,XVectors,YTitle,YVectors,LAtts,Footer,Sm)`

[1] In scatter graphs the attibute that contains the features of a point dataset is `PAtts`.

Besides the features mentioned at the begining of the module chapter, the displayed graph generated calling this predicate has the following distinguish characteristics:

- The plotting area background color is black.
- The cross hairs color is white.
- The axis limits are determined from the data.

Example:

```
graph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,30,59],[25,50]],
  'yaxixtitle',
  [[10,35,40],[25,50]],
  [['line1','Blue','Yellow'],['line2']],
  'footer',
  'natural').
```

graph_b2/13: PREDICATE

`graph_b2(Header,GT,XT,XVs,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

In addition to the features brought up at the begining of the module chapter, this graph has the following:

- The plotting area background color is black.
- The cross hairs color is white.
- You can set the maximum and minimum values for the graph axes.

Example:

```
graph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,10,59],[15,30,35]],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50.5,
  _,
  [['line1','Blue','Yellow'],['line','MediumTurquoise','Plum']],
  'footer',
  'step').
```

graph_w2/9: PREDICATE

`graph_w2(Header,GT,XT,XVectors,YTitle,YVectors,LAtts,Footer,Smooth)`

This predicate is quite similar to `graph_b2/9`. The difference lies in the graph appearance, as you can see below.

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
graph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[10,30,59],[25,50]],
  'yaxixtitle',
  [[10,35,40],[25,40]],
  [['element1','Blue','DarkOrchid'],['element2','DarkOliveGreen',
    'Firebrick']],
  'footer',
  'natural').
```

graph_w2/13: PREDICATE

`graph_w2(Header,GT,XT,XV,XMax,XMin,YT,YVs,YMax,YMin,LAtts,Footer,Smooth)`

This predicate is comparable to `graph_b2/13`. The differences lie in the plot background color and in the cross hairs color, wich are white and black respectively.

Example:

```
graph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[10,30,59],[10,35,40]],
  80,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['element1','Blue','Green'],['element2','Turquoise','Black']],
  'footer',
  'linear').
```

scattergraph_b2/8: PREDICATE

`scattergraph_b2(Header,GT,XT,XVectors,YT,YVectors,PAtts,Footer)`

Apart from the features brought up at the beginning of the chapter, the scatter graph displayed when invoking this predicate has the following features:

- The plotting area background color is black.
- The cross hairs color is white.
- The axis limits are determined from the data.

Example:

```
scattergraph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[10,15,20],[8,30,40]],
  'yaxixtitle',
  [[10,35,20],[15,11,21]],
  [['element1','Blue','Yellow'],['element2','MediumTurquoise','Plum']],
  'footer').
```

scattergraph_b2/12: PREDICATE

`scattergraph_b2(Header,GT,XT,XVs,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

The particular features related to this predicate are described below:

- The plotting area background color is black.
- The cross hairs color is white.
- You can set the minimum and maximum limits of the axes. Data outside the limits will not be plotted.

Example:

```
scattergraph_b2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,30,50],[18,40,59]],
  50,
  _,
  'yaxixtitle',
  [[10,35,40],[25,50,60]],
  50,
  _,
  [['point dataset1'],['point dataset2']],
  'footer').
```

scattergraph_w2/8: PREDICATE

`scattergraph_w2(Header,GTitle,XTitle,XVs,YTitle,YVs,PAtts,Footer)`

This predicate is quite similar to `scattergraph_w1/8` except in the following:

- The plotting area background color is black.
- The cross hairs color is white.
- If the user do not provide the colors of the points, they will be chosen among the lighter ones.

Example:

```
scattergraph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,30,40,15,30,35,20,30]],
  'yaxixtitle',
  [[10,30,40,25,20,25,20,25]],
  [['set1','cross',4]],
  'footer').
```

scattergraph_w2/12: PREDICATE

`scattergraph_w2(Header,GT,XT,XVs,XMax,XMin,YT,YVs,YMax,YMin,PAtts,Footer)`

This predicate is comparable to `scattergraph_w2/13`, the differences between them are listed below:

- The plotting area background color is white.
- The cross hairs color is black.

Example:

```
scattergraph_w2('This is the header text',
  'Graph_title',
  'xaxistitle',
  [[20,10,59],[15,30,50]],
  150,
  5,
  'yaxixtitle',
  [[10,35,40],[25,20,60]],
  _,
  -10,
  [['e1','Blue','Yellow'],['e2','MediumTurquoise','Plum']],
  'footer').
```

177 genmultibar (library)

This module defines predicates which show barchart widgets. These bar charts are somewhat different from the bar charts generated by the predicates in modules genbar1, genbar2, genbar3 and genbar4. Predicates in the present module show different features of each dataset element in one chart at the same time. Each bar chart element is a group of bars, and the element features involve three vectors defined as follows:

- xvector is a list containing the names (atoms) of the bars (n elements). Each bar group will be displayed at uniform intervals.
- yvector is a list that contains m sublists, each one is composed of n elements. The i-sublist contains the y-values of the i-BarAttribute element for all of the XVector elements.
- bar_attributtes is a list containing the appearance features of the bars (m elements). Each element of the list can be partial or complete, which means that you can define as bar attributes only the element name or by setting the element name, its background and foreground color and its stipple pattern.

Other relevant aspects about this widgets are:

- If you don't want to display text in the elements header, barchart title, xaxis title, yaxis title or footer, simply type `''` as the value of the argument.
- The bar chart has a legend, and one entry (symbol and label) per feature group bar.
- The user can either select the appearance of the bars (background color, foreground color and stipple style) or not. See the multibar_attribute type definition.
- Data points can have their bar segments displayed in one of the following modes: stacked, aligned, overlapped or overlayed. They user can change the mode clicking in the checkboxes associated to each mode.
- The predicates test whether the format of the arguments is correct. If one or both vectors are empty, the exception `error2` will be thrown. If the vectors contains elements but are not correct, the exception `error5` or `error6` will be thrown, depending on what is incorrect. `error5` means that `XVector` and each element of `YVector` do not contain the same number of elements or that `YVector` and `BarsAtt` do not contain the same number of elements, while `error6` indicates that not all the `BarsAtt` elements contain a correct number of attributes.

The examples will help you to understand how these predicates should be called.

177.1 Usage and interface (genmultibar)

- **Library usage:**
  `:- use_module(library(genmultibar)).`
- **Exports:**
  - *Predicates:*
    `multibarchart/8`, `multibarchart/10`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/color_pattern`, `chartlib/test_format`, `chartlib/install_utils`, `lists`, `random/random`.

177.2 Documentation on exports (genmultibar)

multibarchart/8: PREDICATE

`multibarchart(Header,BTitle,XTitle,XVector,YTitle,BarsAtts,YVector,Footer)`

The x axis limits are autoarrange. The user can call the predicate in two ways. In the first example the user sets the appearance of the bars, in the second one the appearance features will be chosen by the library.

Example1:

```
multibarchart('This is the Header text',
'My BarchartTitle',
'Processors',
['processor1','processor2','processor3','processor4'],
'Time (seconds)',
[['setup time','MediumTurquoise','Plum','pattern2'],
    ['sleep time','Blue','Green','pattern5'],
    ['running time','Yellow','Plum','pattern1']],
[[20,30,40,50],[10,8,5,35],[60,100,20,50]],
'This is the Footer text').
```

Example2:

```
multibarchart('This is the Header text',
'My BarchartTitle',
'Processors',
['processor1','processor2','processor3','processor4'],
'Time (seconds)',
[['setup time'],['sleep time'],['running time']],
[[20,30,40,50],[10,8,5,35],[60,100,20,50]],
'This is the Footer text').
```

multibarchart/10: PREDICATE

`multibarchart(Header,BT,XT,XVector,YT,BAtts,YVector,YMax,YMin,Footer)`

This predicate is quite similar to `multibarchart/8`, except in that you can choose limits in the y axis. The part of the bars placed outside the limits will not be plotted.

Example2:

```
multibarchart('This is the Header text',
'My BarchartTitle',
'Processors',
['processor1','processor2','processor3','processor4'],
'Time (seconds)',
[['setup time'],['sleep time'],['running time']],
[[20,30,40,50],[10,8,5,35],[60,100,20,50]],
[80],
[0],
'This is the Footer text').
```

177.3 Documentation on internals (genmultibar)

multibar_attribute/1: REGTYPE

```
multibar_attribute([LegendElement]) :-
        atomic(LegendElement).
multibar_attribute([LegendElement,ForegroundColor,BackgroundColor,StipplePatter
        atom(LegendElement),
        color(ForegroundColor),
        color(BackgroundColor),
        pattern(StipplePattern).
```

Defines the attributes of each feature bar along the different datasets.

LegendElement
: Legend element name. It may be a number or an atom. Every `LegendElement` value of the list must be unique.

`ForegColor`
: It sets the Foreground color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`BackgColor`
: It sets the Background color of the bar. Its value must be a valid color, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a color chosen by the library.

`SPattern`
: It sets the stipple of the bar. Its value must be a valid pattern, otherwise the system will throw an exception. If the argument value is a variable, it gets instantiated to a pattern chosen by the library.

xelement/1: REGTYPE

```
xelement(Label) :-
        atomic(Label).
```

This type defines a dataset label. Although `Label` values may be numbers, the will be treated as atoms, So it will be displayed at uniform intervals along the x axis.

178 table_widget1 (library)

In addition to the features explained in the introduction, the predicates exported by this module depict tables in which the font weight for the table elements is bold.

If the arguments are not in a correct format the exception `error8` will be thrown.

178.1 Usage and interface (`table_widget1`)

- **Library usage:**
  `:- use_module(library(table_widget1)).`
- **Exports:**
  - *Predicates:*
    `tablewidget1/4`, `tablewidget1/5`.
  - *Regular Types:*
    `table/1`, `image/1`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

178.2 Documentation on exports (`table_widget1`)

tablewidget1/4: PREDICATE

`tablewidget1(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The user does not choose a background image.

Example:

```
tablewidget1('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
         ['Average Tasks per fork','7.5']],
     'Footer text').
```

tablewidget1/5: PREDICATE

`tablewidget1(Title,Header,ElementTable,Footer,BackgroundImage)`

Shows a regular table in a window. The user must set a background image. See the `image/1` type definition.

Example:

```
tablewidget1('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
         ['Average Tasks per fork','7.5']],
     'Footer text',
     './images/rain.gif')
```

table/1: REGTYPE

A table is a list of rows, each row must contain the same number of elements, otherwise the table wouldn't be regular and an exception will be thrown by the library. The rows list may not be empty.

```
table([X]) :-
        row(X).
table([X|Xs]) :-
        row(X),
        table(Xs).
```

image/1: REGTYPE

Some predicates allow the user to set the widget background image, whose is what this type is intended for. The user has to take into account the following restrictions:

- The image must be in gif format.
- The file path must be absolute.

178.3 Documentation on internals (`table_widget1`)

row/1: REGTYPE

```
row([X]) :-
        cell_value(X).
row([X|Xs]) :-
        cell_value(X),
        row(Xs).
```

Each row is a list of elements whose type is `cell_value/1`. A row cannot be an empty list, as you can see in the definition type.

row/1: REGTYPE

```
row([X]) :-
        cell_value(X).
row([X|Xs]) :-
        cell_value(X),
        row(Xs).
```

Each row is a list of elements whose type is `cell_value/1`. A row cannot be an empty list, as you can see in the definition type.

cell_value/1: REGTYPE

This type defines the possible values that a table element have. If any cell value is `''`, the cell will be displayed empty.

```
cell_value(X) :-
        atomic(X).
```

179 table_widget2 (library)

In addition to the features explained in the introduction, predicates exported by this module display tables in which the font weight for the elements placed in the first row is bold. The remaining elements are in medium weight font.

If the arguments are not in a correct format the exception `error8` will be thrown.

179.1 Usage and interface (table_widget2)

- **Library usage:**
  `:- use_module(library(table_widget2)).`
- **Exports:**
  - *Predicates:*
    `tablewidget2/4`, `tablewidget2/5`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/table_widget1`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

179.2 Documentation on exports (table_widget2)

tablewidget2/4: PREDICATE

`tablewidget2(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The system sets a default background image for the widget.

Example:

```
tablewidget2('COM Features',
     'Extracted from "Inside COM" book ',
     [['Feature','Rich people','Bean Plants','C++','COM'],
       ['Edible','Yes','Yes','No','No'],
       ['Supports inheritance','Yes','Yes','Yes','Yes and No'],
       ['Can run for President','Yes','No','No','No']],
     'What do you think about COM?').
```

tablewidget2/5: PREDICATE

`tablewidget2(Title,Header,ElementTable,Footer,BackgroundImage)`

This predicate and `tablewidget2/4` are quite similar, except that in the already one defined you must set the background image.

Example:

```
tablewidget2('COM Features',
     'Extracted from "Inside COM" book ',
     [['Feature','Rich people','Bean Plants','C++','COM'],
       ['Edible','Yes','Yes','No','No'],
```

```
  ['Supports inheritance','Yes','Yes','Yes','Yes and No'],
  ['Can run for President','Yes','No','No','No']],
'What do you think about COM?',
'./images/rain.gif').
```

180 table_widget3 (library)

The predicates exported by this module display data in a regular table, as we brought up in the introduction. Both predicates have in common that the font weight for the elements placed in the first column is bold and the remaining elements are in medium font weight.

If the arguments are not in a correct format the exception `error8` will be thrown.

180.1 Usage and interface (table_widget3)

- **Library usage:**
  `:- use_module(library(table_widget3)).`
- **Exports:**
  - *Predicates:*
    `tablewidget3/4`, `tablewidget3/5`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/table_widget1`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

180.2 Documentation on exports (table_widget3)

tablewidget3/4: PREDICATE

`tablewidget3(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The user does not choose a background image.

Example:

```
tablewidget3('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
       ['Tasks per fork','7.5']],
     'Footer text').
```

tablewidget3/5: PREDICATE

`tablewidget3(Title,Header,ElementTable,Footer,BackgroundImage)`

Shows a regular table in a window. The user must set a background image.

Example:

```
tablewidget3('This is the title',
     'Header text',
     [['Number of processors','8'],['Average processors','95'],
         ['Average Tasks per fork','7.5']],
     'Footer text',
     './images/rain.gif')
```

181 table_widget4 (library)

In addition to the features explained in the introduction, predicates exported by this module display tables in which the font weight for the elements placed in the first row and column is bold. The remaining elements are in medium weight font.

If the arguments are not in a correct format the exception `error8` will be thrown.

181.1 Usage and interface (table_widget4)

- **Library usage:**
  `:- use_module(library(table_widget4)).`
- **Exports:**
  - *Predicates:*
    `tablewidget4/4`, `tablewidget4/5`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/genbar1`, `chartlib/bltclass`, `chartlib/table_widget1`, `chartlib/test_format`, `chartlib/install_utils`, `lists`.

181.2 Documentation on exports (table_widget4)

tablewidget4/4: PREDICATE

`tablewidget4(Title,Header,ElementTable,Footer)`

Shows a regular table in a window. The system sets a default background image for the widget.

Example:

```
tablewidget4('Some sterEUtypes',
  'Source: Eurostat yearbook, 1999',
  [['Country','Adult alcohol intake per year (litres)',
       'Cigarettes smoked per day per adult',
            'Suicides per 100000 people'],
      ['Finland','8.4','2.2','26.3'],['Spain','11.4','5.3','7.5'],
      ['Austria','11.9','4.6','20.7'],['Britain','9.4','4.2','7.1'],
      ['USA','4.7','4.9','13'],['European Union','11.1','4.5','11.9']],
  'This is part of the published table').
```

tablewidget4/5: PREDICATE

`tablewidget4(Title,Header,ElementTable,Footer,BackgroundImage)`

This predicate and `tablewidget4/4` are comparable, except that in the already defined you must set the background image.

Example:

```
tablewidget4('Some sterEUtypes',
  'Source: Eurostat yearbook, 1999',
```

```
[['Country','Adult alcohol intake per year (litres)',
     'Cigarettes smoked per day per adult',
         'Suicides per 100000 people'],
    ['Finland','8.4','2.2','26.3'],['Spain','11.4','5.3','7.5'],
    ['Austria','11.9','4.6','20.7'],['Britain','9.4','4.2','7.1'],
    ['USA','4.7','4.9','13'],['European Union','11.1','4.5','11.9']],
'This is part of the published table',
'./images/rain.gif').
```

182 test_format (library)

Most of the predicates exported by this module perform some checks to determine whether the arguments attain some conditions or not. In the second case an exception will be thrown. To catch the exceptions you can use the following metapredicates when invoking chartlib exported predicates:

- `chartlib_text_error_protect/1`
- `chartlib_text_error_protect/1`

Both metapredicates are defined in the chartlib_errhandle module that comes with this library. Some of the predicates have a `Predicate` argument which will be used in case of error to show which chartlib predicate causes the error.

182.1 Usage and interface (test_format)

- **Library usage:**
  `:- use_module(library(test_format)).`
- **Exports:**
  - *Predicates:*
    `equalnumber/3`, `not_empty/4`, `not_empty/3`, `check_sublist/4`, `valid_format/4`, `vectors_format/4`, `valid_vectors/4`, `valid_attributes/2`, `valid_table/2`.
- **Other modules used:**
  - *System library modules:*
    `chartlib/bltclass`, `lists`.

182.2 Documentation on exports (test_format)

equalnumber/3: PREDICATE

`equalnumber(X,Y,Predicate)`

Test whether the list `X` and the list `Y` contain the same number of elements.

not_empty/4: PREDICATE

`not_empty(X,Y,Z,Predicate)`

Tests whether at least one the lists `X`, `Y` or `Z` are empty.

not_empty/3: PREDICATE

`not_empty(X,Y,Predicate)`

Tests whether the lists `X` or `Y` are empty.

check_sublist/4: PREDICATE

`check_sublist(List,Number,Number,Predicate)`

Tests if the number of elements in each sublist of `List` is `Number1` or `Number2`.

valid_format/4: PREDICATE

`valid_format(XVector,YVector,BarsAttributes,Predicate)`

Tests the following restrictions:

- The `XVector` number of elements is the same as each `YVector` sublist number of elements.
- The `YVector` length is equal to `BarsAttributes` length.

vectors_format/4: PREDICATE

`vectors_format(XVector,YVectors,LinesAttributes,Predicate)`

Tests the following conditions:

- `YVectors` list and `LinesAttributes` list have the same number of elements.
- `XVector` list and each `YVectors` element have the same number of elements.
- Each sublist of `LinesAttributes` is composed of 5, 3 or 1 elements.

valid_vectors/4: PREDICATE

`valid_vectors(XVector,YVectors,LinesAttributes,Predicate)`

Tests the following conditions:

- `XVector` list, `YVectors` list and `LinesAttributes` list have the same number of elements.
- Each sublist of `LinesAttributes` is composed of 5, 3 or 1 element.

valid_attributes/2: PREDICATE

`valid_attributes(BarsAttibuttes,Predicate)`

Check if each `BarsAttibuttes` element is a list composed of one or four elements.

valid_table/2: PREDICATE

`valid_table(ElementTable,Predicate)`

All of the `ElementTable` sublists have the same number of elements and are not empty.

183 ProVRML - a Prolog interface for VRML

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Version: 0.1#1 (1998/12/10, 16:19:45 MET)

ProVRML is Prolog library to handle VRML code. The library consists of modules to handle the tokenising, that is breaking the VRML code into smaller parts that can be analysed further. The further analysis will be the parsing. This is a complex part of the library and consists of several modules to handle errors and value check. When the parsing is done we have the Prolog terms of the VRML code. The terms are quite similar to the origin VRML code and can easily be read if you recognise that syntax.

This Prolog terms of the VRML code is then possible to use for analysis, reconstruction, reverse enginering, building blocks for automatic generation of VRML code. There are several possibilities and these are only some of them.

When you are done with the Prolog terms for the code, you would probably want to reverse the action and return to VRML code. This is done with the code generation modules. These are built up in more or less the same manner as the parser modules.

183.1 Usage and interface (provrml)

- **Library usage:**
  `:- use_module(library(provrml)).`
- **Exports:**
  - *Predicates:*
    `vrml_web_to_terms/2`, `vrml_file_to_terms/2`, `vrml_web_to_terms_file/2`, `vrml_file_to_terms_file/2`, `terms_file_to_vrml/2`, `terms_file_to_vrml_file/2`, `terms_to_vrml_file/2`, `terms_to_vrml/2`, `vrml_to_terms/2`, `vrml_in_out/2`, `vrml_http_access/2`.
- **Other modules used:**
  - *System library modules:*
    `pillow/http`, `pillow/html`, `provrml/io`, `provrml/parser`, `provrml/generator`, `lists`.

183.2 Documentation on exports (provrml)

vrml_web_to_terms/2: PREDICATE

Usage: `vrml_web_to_terms(+WEBAddress,-Terms)`

- *Description:* Given a address to a VRML-document on the Internet, the predicate will return the prolog-terms.
- *Call and exit should be compatible with:*
  `+WEBAddress` is an atom. (`basic_props:atm/1`)
  `-Terms` is a string (a list of character codes). (`basic_props:string/1`)

vrml_file_to_terms/2: PREDICATE

Usage 1: `vrml_file_to_terms(+FileName,-Term)`

- *Description:* Given a filename containing a VRML-file the predicate returns the prolog terms corresponding.
- *Call and exit should be compatible with:*

  `+FileName` is an atom. (`basic_props:atm/1`)

  `-Term` is an atom. (`basic_props:atm/1`)

Usage 2: `vrml_file_to_terms(+FileName,+Terms)`

- *Description:* Given a filename containing a VRML-file and a filename, the predicate write the prolog terms corresponding to the filename.
- *Call and exit should be compatible with:*

  `+FileName` is an atom. (`basic_props:atm/1`)

  `+Terms` is an atom. (`basic_props:atm/1`)

vrml_web_to_terms_file/2: PREDICATE

Usage: `vrml_web_to_terms_file(+WEBAddress,+FileName)`

- *Description:* Given a address to a VRML-document on the Internet and a filename, the predicate will write the prolog_terms to the file.
- *Call and exit should be compatible with:*

  `+WEBAddress` is an atom. (`basic_props:atm/1`)

  `+FileName` is an atom. (`basic_props:atm/1`)

vrml_file_to_terms_file/2: PREDICATE

No further documentation available for this predicate.

terms_file_to_vrml/2: PREDICATE

Usage: `terms_file_to_vrml(+FileName,-List)`

- *Description:* From a given filename with prologterms on the special format, the predicate returns the corresponding VRML-code.
- *Call and exit should be compatible with:*

  `+FileName` is an atom. (`basic_props:atm/1`)

  `-List` is a string (a list of character codes). (`basic_props:string/1`)

terms_file_to_vrml_file/2: PREDICATE

Usage: `terms_file_to_vrml_file(+Atom,+Atom)`

- *Description:* From a given filename with prologterms on the special format, the predicate writes the corresponding VRML-code to second filename.
- *Call and exit should be compatible with:*

  `+Atom` is an atom. (`basic_props:atm/1`)

  `+Atom` is an atom. (`basic_props:atm/1`)

terms_to_vrml_file/2: PREDICATE

Usage: `terms_to_vrml_file(+Term,+FileName)`

- *Description:* Given prolog-terms the predicate writes the corresponding VRML-code to the given file.
- *Call and exit should be compatible with:*

  `+Term` is an atom. (`basic_props:atm/1`)

  `+FileName` is an atom. (`basic_props:atm/1`)

terms_to_vrml/2: PREDICATE

Usage: `terms_to_vrml(+Term,-VRMLCode)`

- *Description:* Given prolog-terms the predicate returns a list with the corresponding VRML-code.
- *Call and exit should be compatible with:*

  `+Term` is an atom. (`basic_props:atm/1`)

  `-VRMLCode` is a string (a list of character codes). (`basic_props:string/1`)

vrml_to_terms/2: PREDICATE

Usage: `vrml_to_terms(+VRMLCode,-Terms)`

- *Description:* Given a list with VRML-code the predicate will return the corresponding prolog-terms.
- *Call and exit should be compatible with:*

  `+VRMLCode` is a string (a list of character codes). (`basic_props:string/1`)

  `-Terms` is an atom. (`basic_props:atm/1`)

vrml_in_out/2: PREDICATE

Usage: `vrml_in_out(+FileName,+FileName)`

- *Description:* This is a controll-predicate that given a filename to a VRML-file and a filename, the predicate will read the VRML-code. Transform it to prolog-terms and then transform it back to VRRML-code and write it to the latter file.
- *Call and exit should be compatible with:*

  `+FileName` is an atom. (`basic_props:atm/1`)

  `+FileName` is an atom. (`basic_props:atm/1`)

vrml_http_access/2: PREDICATE

Usage: `vrml_http_access(+ReadFilename,+BaseFilename)`

- *Description:* Given a web-address to a VRML-file the predicate will load the code, write it first to the second argument with extension '_first.wrl'. Then it transform the code to prolog terms and write it with the extension '.term'. Transform it back to VRML-code and write it to the filename with '.wrl. A good test-predicate.
- *Call and exit should be compatible with:*

  `+ReadFilename` is an atom. (`basic_props:atm/1`)

  `+BaseFilename` is an atom. (`basic_props:atm/1`)

183.3 Documentation on internals (provrml)

read_page/2: PREDICATE

Usage: `read_page(+WEBAddress,-Data)`

- *Description:* This routine reads a page on the web using pillow routines.
- *Call and exit should be compatible with:*

  `+WEBAddress` is an atom. (`basic_props:atm/1`)

  `-Data` is a string (a list of character codes). (`basic_props:string/1`)

184 boundary (library)

Version: 0.1#1 (1998/12/14, 19:22:27 MET)

This module offers predicate to check values according to their boundaries and offers lists of possible node ascendents.

184.1 Usage and interface (boundary)

- **Library usage:**
  `:- use_module(library(boundary)).`
- **Exports:**
  - *Predicates:*
    `boundary_check/3`, `boundary_rotation_first/2`, `boundary_rotation_last/2`, `reserved_words/1`, `children_nodes/1`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `provrml/internal_types`, `provrml/error`.

184.2 Documentation on exports (boundary)

boundary_check/3: PREDICATE

Usage: `boundary_check(+Value_to_check,+Init_value,+Bound)`

- *Description:* This predicate check the boundaries of the given value according to the boudary values. If the value is wrong according to the boundaries, the value is checked according to the initial value given. If the value continues to be wrong, an error will be raised accordingly.
- *Call and exit should be compatible with:*

`+Value_to_check` is an atom.	(`basic_props:atm/1`)
`+Init_value` is a list of `atm`s.	(`basic_props:list/2`)
`+Bound` is a variable interval.	(`internal_types:bound/1`)

boundary_rotation_first/2: PREDICATE

Usage: `boundary_rotation_first(+Bound_double,-Bound)`

- *Description:* The predicate will extract the first bounds from a double bound.
- *Call and exit should be compatible with:*

`+Bound_double` is a variable interval.	(`internal_types:bound_double/1`)
`-Bound` is a variable interval.	(`internal_types:bound/1`)

boundary_rotation_last/2: PREDICATE

Usage: `boundary_rotation_last(+Bound_double,-Bound)`

- *Description:* The predicate will extract the last bounds from a double bound.
- *Call and exit should be compatible with:*

  `+Bound_double` is a variable interval. (`internal_types:bound_double/1`)

  `-Bound` is a variable interval. (`internal_types:bound/1`)

reserved_words/1: PREDICATE

Usage: `reserved_words(-List)`

- *Description:* Returns a list with the reserved words, words prohibited to use in cases not appropiated.
- *Call and exit should be compatible with:*

  `-List` is a list of `atm`s. (`basic_props:list/2`)

children_nodes/1: PREDICATE

Usage: `children_nodes(-List)`

- *Description:* Returns a list of all nodes possible as children nodes.
- *Call and exit should be compatible with:*

  `-List` is a list of `atm`s. (`basic_props:list/2`)

185 dictionary (library)

Version: 0.1 (1998/12/7, 15:57:36 MET)

This module contains the fixed dictionary. All the nodes in VRML with their associated fields.

185.1 Usage and interface (dictionary)

- **Library usage:**
  `:- use_module(library(dictionary)).`
- **Exports:**
  - *Predicates:*
    `dictionary/6`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `provrml/internal_types`.

185.2 Documentation on exports (dictionary)

dictionary/6: PREDICATE

Usage 1: `dictionary(?NodeTypeId,?AccessType,?FieldTypeId,?FieldId,-Init_value,-Boundary)`

- *Description:* To lookup information about the nodes, getting their properties. Note that the type returned for the bound can be of two different types bound or bound_double. The rotation type have one bound for the directions and one for the degree of rotation.
- *Call and exit should be compatible with:*

`?NodeTypeId` is an atom.	(`basic_props:atm/1`)
`?AccessType` is an atom.	(`basic_props:atm/1`)
`?FieldTypeId` is an atom.	(`basic_props:atm/1`)
`?FieldId` is an atom.	(`basic_props:atm/1`)
`-Init_value` is a list of `atm`s.	(`basic_props:list/2`)
`-Boundary` is a variable interval.	(`internal_types:bound/1`)

Usage 2: `dictionary(?NodeTypeId,?AccessType,?FieldTypeId,?FieldId,-Init_value,-Boundary)`

- *Description:* To lookup information about the nodes, getting their properties. Note that the type returned for the bound can be of two different types bound or bound_double. The rotation type have one bound for the directions and one for the degree of rotation.
- *Call and exit should be compatible with:*

`?NodeTypeId` is an atom.	(`basic_props:atm/1`)
`?AccessType` is an atom.	(`basic_props:atm/1`)

?FieldTypeId is an atom. (basic_props:atm/1)
?FieldId is an atom. (basic_props:atm/1)
-Init_value is a list of atms. (basic_props:list/2)
-Boundary is a variable interval. (internal_types:bound_double/1)

186 dictionary_tree (library)

Version: 0.1 (1999/1/14, 15:57:36 MET)

This module offers a dynamic tree structured dictionary a bit combined with predicates that gives it the useability to be the dictionary for the parser.

186.1 Usage and interface (dictionary_tree)

- **Library usage:**
  `:- use_module(library(dictionary_tree)).`
- **Exports:**
  - *Predicates:*
    `create_dictionaries/1`, `is_dictionaries/1`, `get_definition_dictionary/2`, `get_prototype_dictionary/2`, `dictionary_insert/5`, `dictionary_lookup/5`, `merge_tree/2`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `provrml/internal_types`.

186.2 Documentation on exports (dictionary_tree)

create_dictionaries/1: PREDICATE

Usage: `create_dictionaries(-Dictionary)`

- *Description:* Returns a dictionary. A general name was used if the user would like to change the code to include more dictionaries.
- *Call and exit should be compatible with:*
  `-Dictionary` is a dictionary. (`internal_types:dictionary/1`)

is_dictionaries/1: PREDICATE

Usage: `is_dictionaries(?Dictionary)`

- *Description:* Is the argument a dictionary is solved by this predicate.
- *Call and exit should be compatible with:*
  `?Dictionary` is a dictionary. (`internal_types:dictionary/1`)

get_definition_dictionary/2: PREDICATE

Usage: `get_definition_dictionary(+Dictionary,-Tree)`

- *Description:* Returns the definition dictionary (for the moment there is only one dictionary), which is a tree representation.
- *Call and exit should be compatible with:*
  `+Dictionary` is a dictionary. (`internal_types:dictionary/1`)
  `-Tree` is a tree structure. (`internal_types:tree/1`)

get_prototype_dictionary/2: PREDICATE

Usage: `get_prototype_dictionary(+Dictionary,-Tree)`

- *Description:* Returns the prototype dictionary (for the moment there is only one dictionary), which is a tree representation.
- *Call and exit should be compatible with:*

`+Dictionary` is a dictionary.	(`internal_types:dictionary/1`)
`-Tree` is a tree structure.	(`internal_types:tree/1`)

dictionary_insert/5: PREDICATE

Usage: `dictionary_insert(+Key,+Type,+Field,+Dictionary,?Info)`

- *Description:* The predicate will search for the place for the Key and return Info, if the element inserted had a post before (same key value) multiple else new. The dictionary is dynamic and do not need output because of using unbinded variables.
- *Call and exit should be compatible with:*

`+Key` is an atom.	(`basic_props:atm/1`)
`+Type` is an atom.	(`basic_props:atm/1`)
`+Field` is any term.	(`basic_props:term/1`)
`+Dictionary` is a tree structure.	(`internal_types:tree/1`)
`?Info` is an atom.	(`basic_props:atm/1`)

dictionary_lookup/5: PREDICATE

Usage: `dictionary_lookup(+Key,?Type,?Field,+Dictionary,-Info)`

- *Description:* The predicate will search for the Key and return Info;defined or undefined accordingly. If defined the fields will be filled as well. The predicate do not insert the element.
- *Call and exit should be compatible with:*

`+Key` is an atom.	(`basic_props:atm/1`)
`?Type` is an atom.	(`basic_props:atm/1`)
`?Field` is any term.	(`basic_props:term/1`)
`+Dictionary` is a dictionary.	(`internal_types:dictionary/1`)
`-Info` is an atom.	(`basic_props:atm/1`)

merge_tree/2: PREDICATE

Usage: `merge_tree(+Tree,+Tree)`

- *Description:* The predicate can be used for adding a tree dictionary to another one (the second). It will remove equal posts but posts with a slight difference will be inserted. The resulting tree will be the second tree.
- *Call and exit should be compatible with:*

`+Tree` is a tree structure.	(`internal_types:tree/1`)
`+Tree` is a tree structure.	(`internal_types:tree/1`)

187 error (library)

Author(s): Göran Smedbäck.
Version: 0.1#3 (1998/12/14, 19:14:44 MET)
This file implements error predicates of different types.

187.1 Usage and interface (error)

- **Library usage:**
  `:- use_module(library(error)).`
- **Exports:**
  - *Predicates:*
    `error_vrml/1`, `output_error/1`.

187.2 Documentation on exports (error)

error_vrml/1: PREDICATE

Usage: `error_vrml(+Structure)`

- *Description:* Given a structure with the error type as its head with possible arguments, it will write the associated error-text.
- *Call and exit should be compatible with:*
  `+Structure` is any term. (`basic_props:term/1`)

output_error/1: PREDICATE

Usage: `output_error(+Message)`

- *Description:* This predicate will print the error message given as the argument. This predicate is used for warnings that only needs to be given as information and not necessarily give an error by the VRML browser.
- *Call and exit should be compatible with:*
  `+Message` is a list of `atms`. (`basic_props:list/2`)

188 field_type (library)

Version: 0.1 (1998/12/9, 13:30:46 MET)

188.1 Usage and interface (field_type)

- **Library usage:**
  `:- use_module(library(field_type)).`
- **Exports:**
  - *Predicates:*
    `fieldType/1`.

188.2 Documentation on exports (field_type)

fieldType/1: PREDICATE

Usage: `fieldType(+FieldTypeId)`

- *Description:* Boolean predicate used to check the fieldTypeId with the defiened.
- *Call and exit should be compatible with:*
  `+FieldTypeId` is an atom. (`basic_props:atm/1`)

189 field_value (library)

Version: 0.1 (1998/12/9, 13:51:13 MET)

189.1 Usage and interface (`field_value`)

- **Library usage:**
  `:- use_module(library(field_value)).`
- **Exports:**
  - *Predicates:*
    `fieldValue/6`, `mfstringValue/5`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `provrml/parser`, `provrml/parser_util`, `provrml/error`.

189.2 Documentation on exports (`field_value`)

fieldValue/6: PREDICATE

No further documentation available for this predicate.

mfstringValue/5: PREDICATE

No further documentation available for this predicate.

190 field_value_check (library)

Version: 0.1 (1998/12/9, 14:36:55 MET)

190.1 Usage and interface (field_value_check)

- **Library usage:**
  `:- use_module(library(field_value_check)).`
- **Exports:**
  - *Predicates:*
    `fieldValue_check/8`, `mfstringValue/7`.
- **Other modules used:**
  - *System library modules:*
    `lists`, `provrml/io`, `provrml/generator_util`, `provrml/boundary`, `provrml/tokeniser`, `provrml/generator`, `provrml/parser_util`.

190.2 Documentation on exports (field_value_check)

fieldValue_check/8: PREDICATE

No further documentation available for this predicate.

mfstringValue/7: PREDICATE

No further documentation available for this predicate.

191 generator (library)

191.1 Usage and interface (generator)

- **Library usage:**
  `:- use_module(library(generator)).`
- **Exports:**
  - *Predicates:*
    `generator/2`, `nodeDeclaration/4`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `provrml/lookup`, `provrml/io`, `provrml/generator_util`, `provrml/parser_util`, `provrml/error`, `provrml/internal_types`.

191.2 Documentation on exports (generator)

generator/2: PREDICATE

Usage: `generator(+Terms,-VRML)`

- *Description:* This predicate is the generator of VRML code. It accepts a list of terms that is correct VRML code, other kind of terms will be rejected will errormessage accordingly. The output is a string of correct VRML code, acceptable for VRML browsers.
- *Call and exit should be compatible with:*
  `+Terms` is a list of `terms`s. (`basic_props:list/2`)
  `-VRML` is a string (a list of character codes). (`basic_props:string/1`)

nodeDeclaration/4: PREDICATE

No further documentation available for this predicate.

192 generator_util (library)

192.1 Usage and interface (generator_util)

- **Library usage:**
  `:- use_module(library(generator_util)).`
- **Exports:**
  - *Predicates:*
    `reading/4`, `reading/5`, `reading/6`, `open_node/6`, `close_node/5`, `close_nodeGut/4`, `open_PROTO/4`, `close_PROTO/6`, `open_EXTERNPROTO/5`, `close_EXTERNPROTO/6`, `open_DEF/5`, `close_DEF/5`, `open_Script/5`, `close_Script/5`, `decompose_field/3`, `indentation_list/2`, `start_vrmlScene/4`, `remove_comments/4`.
- **Other modules used:**
  - *System library modules:*
    `provrml/error`, `lists`, `provrml/io`, `provrml/field_value_check`, `provrml/lookup`, `provrml/parser_util`.

192.2 Documentation on exports (generator_util)

reading/4: PREDICATE

Usage 1: `reading(+IS,+NodeTypeId,+ParseIn,-ParseOut)`

- *Description:* This predicate will refer to a formerly introduced interface. We do a checkup of the access type and output the values.
- *Call and exit should be compatible with:*

`+IS` is an atom.	(`basic_props:atm/1`)
`+NodeTypeId` is an atom.	(`basic_props:atm/1`)
`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

Usage 2: `reading(+nodeGut,+NodeName,+ParseIn,-ParseOut)`

- *Description:* This predicate will read a node gut and will check the field according to the name.
- *Call and exit should be compatible with:*

`+nodeGut` is an atom.	(`basic_props:atm/1`)
`+NodeName` is an atom.	(`basic_props:atm/1`)
`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

reading/5: PREDICATE

No further documentation available for this predicate.

reading/6: PREDICATE

No further documentation available for this predicate.

open_node/6: PREDICATE

No further documentation available for this predicate.

close_node/5: PREDICATE

No further documentation available for this predicate.

close_nodeGut/4: PREDICATE

No further documentation available for this predicate.

open_PROTO/4: PREDICATE

No further documentation available for this predicate.

close_PROTO/6: PREDICATE

No further documentation available for this predicate.

open_EXTERNPROTO/5: PREDICATE

No further documentation available for this predicate.

close_EXTERNPROTO/6: PREDICATE

No further documentation available for this predicate.

open_DEF/5: PREDICATE

No further documentation available for this predicate.

close_DEF/5: PREDICATE

No further documentation available for this predicate.

open_Script/5: PREDICATE

No further documentation available for this predicate.

close_Script/5: PREDICATE

No further documentation available for this predicate.

decompose_field/3: PREDICATE

No further documentation available for this predicate.

indentation_list/2: PREDICATE

Usage: `indentation_list(+Parse,-IndList)`

- *Description:* This predcate will construct a list with indentations to be output before text. The information of the indentations is inside the parse structure.
- *Call and exit should be compatible with:*

  `+Parse` is a parse structure. (`internal_types:parse/1`)

  `-IndList` is a list of `atm`s. (`basic_props:list/2`)

start_vrmlScene/4: PREDICATE

No further documentation available for this predicate.

remove_comments/4: PREDICATE

Usage: `remove_comments(+Value,-CommentsBefore,-ValueClean,-CommentsAfter)`

- *Description:* The predicate will remove comments and return the comments before and after the pure value.
- *Call and exit should be compatible with:*

  `+Value` is a list of `atm`s. (`basic_props:list/2`)

  `-CommentsBefore` is a list of `atm`s. (`basic_props:list/2`)

  `-ValueClean` is an atom. (`basic_props:atm/1`)

  `-CommentsAfter` is a list of `atm`s. (`basic_props:list/2`)

193 internal_types (library)

Version: 0.1#2 (1998/12/17, 12:37:23 MET)

These are the internal data types used in the predicates. They are only used to simplify this documentation and make it more understandable.

Implemented by Göran Smedbäck

193.1 Usage and interface (internal_types)

- **Library usage:**

  ```
  :- use_module(library(internal_types)).
  ```

- **Exports:**
  - *Regular Types:*

    `bound/1`, `bound_double/1`, `dictionary/1`, `environment/1`, `parse/1`, `tree/1`, `whitespace/1`.

193.2 Documentation on exports (internal_types)

bound/1: REGTYPE

Min is a number or an atom that indicates the minimal value, Max indicates the maximal.

```
bound(bound(Min,Max)) :-
        atm(Min),
        atm(Max).
```

Usage: `bound(Bound)`

- *Description:* `Bound` is a variable interval.

bound_double/1: REGTYPE

Min is a number or an atom that indicates the minimal value, Max indicates the maximal. The first two for some value and the second pair for some other. Typically used for types that are compound, e.g., rotationvalue.

```
bound_double(bound(Min0,Max0,Min1,Max1)) :-
        atm(Min0),
        atm(Max0),
        atm(Min1),
        atm(Max1).
```

Usage: `bound_double(Bound)`

- *Description:* `Bound` is a variable interval.

dictionary/1: REGTYPE

Dic is a tree structure and is used as the internal representation of the dictionary.

```
dictionary(dic(Dic)) :-
        tree(Dic).
```

Usage: `dictionary(Dictionary)`

– *Description:* `Dictionary` is a dictionary.

environment/1: REGTYPE

EnvironmentType one of 'DEF','PROTO','EXTERNPROTO' with the name Name. Whitespace is a structure with whitespace information.

```
environment(env(Env,Name,WhiteSpace)) :-
        atm(Env),
        atm(Name),
        whitespace(WhiteSpace).
```

Usage: `environment(Environment)`

– *Description:* `Environment` is an environment structure.

parse/1: REGTYPE

In is the list of tokens to parse and Out is the resulting list after the parsing. Env is of type env and is the environment-structure.The dictinonary Dic contains created information and structures.

```
parse(parse(In,Out,Env,Dic)) :-
        list(In),
        list(Out),
        environment(Env),
        dictionary(Dic).
```

Usage: `parse(Parse)`

– *Description:* `Parse` is a parse structure.

tree/1: REGTYPE

Key is the search-key, Leaf is the information, Left and Right are more dictionary posts, where Left have less Key-value.

```
tree(tree(Key,Leaf,Left,Right)) :-
        atm(Key),
        leaf(Leaf),
        tree(Left),
        tree(Right).
```

Usage: `tree(Tree)`

– *Description:* `Tree` is a tree structure.

whitespace/1: REGTYPE

The Row and Indentation information. The row information used when parsing the VRML code to give accurate error position and the indentation is used when generating VRML code from terms.

```
whitespace(w(Row,Indentation)) :-
        number(Row),
        number(Indentation).
```

Usage: `whitespace(Whitespace)`

– *Description:* `Whitespace` is a whitespace structure.

194 io (library)

Version: 0.1#2 (1998/12/2)
This file implements I/O predicates of different types.
Implemented by Göran Smedbäck

194.1 Usage and interface (io)

- **Library usage:**
  `:- use_module(library(io)).`
- **Exports:**
  - *Predicates:*
    `out/1`, `out/3`, `convert_atoms_to_string/2`, `read_terms_file/2`, `write_terms_file/2`, `read_vrml_file/2`, `write_vrml_file/2`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `format`.

194.2 Documentation on exports (io)

out/1: PREDICATE

Usage: `out(+ListOfOutput)`

- *Description:* The predicate used is out/3 (DCG) where we will 'save' the output in the second argument. The tird argument is the rest, nil.
- *Call and exit should be compatible with:*
  `+ListOfOutput` is a list of `atm`s. (`basic_props:list/2`)

out/3: PREDICATE

No further documentation available for this predicate.

convert_atoms_to_string/2: PREDICATE

Usage: `convert_atoms_to_string(+Atoms,-String)`

- *Description:* The predicate transforms a list of atoms to a string.
- *Call and exit should be compatible with:*
  `+Atoms` is a list of `atm`s. (`basic_props:list/2`)
  `-String` is a list of `num`s. (`basic_props:list/2`)

read_terms_file/2: PREDICATE

Usage: `read_terms_file(+Filename,-Term)`

- *Description:* Given a filename to a file with terms, the predicate reads the terms and are returned in the second argument. `Filename` is an atom and `Term` is the read prolog terms.
- *Call and exit should be compatible with:*

  `+Filename` is an atom. (`basic_props:atm/1`)

  `-Term` is an atom. (`basic_props:atm/1`)

write_terms_file/2: PREDICATE

Usage: `write_terms_file(+FileName,+List)`

- *Description:* Given a filename and a list of terms the predicate will write them down to the file.
- *Call and exit should be compatible with:*

  `+FileName` is an atom. (`basic_props:atm/1`)

  `+List` is a list of `atm`s. (`basic_props:list/2`)

read_vrml_file/2: PREDICATE

Usage: `read_vrml_file(+FileName,-Data)`

- *Description:* Given a filename, the predicate returns the substance.
- *Call and exit should be compatible with:*

  `+FileName` is an atom. (`basic_props:atm/1`)

  `-Data` is a string (a list of character codes). (`basic_props:string/1`)

write_vrml_file/2: PREDICATE

Usage: `write_vrml_file(+FileName,+Data)`

- *Description:* Given a filename and data in form of a string, the predicate will write the data to the named file.
- *Call and exit should be compatible with:*

  `+FileName` is an atom. (`basic_props:atm/1`)

  `+Data` is a string (a list of character codes). (`basic_props:string/1`)

195 lookup (library)

Version: 0.1 (1999/1/14, 13:30:46 MET)

195.1 Usage and interface (lookup)

- **Library usage:**
  `:- use_module(library(lookup)).`
- **Exports:**
  - *Predicates:*
    `create_proto_element/3`, `get_prototype_interface/2`, `get_prototype_definition/2`, `lookup_check_node/4`, `lookup_check_field/6`, `lookup_check_interface_fieldValue/8`, `lookup_field/4`, `lookup_route/5`, `lookup_fieldTypeId/1`, `lookup_get_fieldType/4`, `lookup_field_access/4`, `lookup_set_def/3`, `lookup_set_prototype/4`, `lookup_set_extern_prototype/4`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `provrml/error`, `provrml/io`, `provrml/parser_util`, `provrml/dictionary`, `provrml/dictionary_tree`, `provrml/field_value_check`, `provrml/boundary`, `provrml/generator_util`, `provrml/field_type`.

195.2 Documentation on exports (lookup)

create_proto_element/3: PREDICATE

Usage: `create_proto_element(+Interface,+Definition,-Proto)`

- *Description:* The predicate will construct a proto structure containing the interface and the definition.
- *Call and exit should be compatible with:*

`+Interface` is any term. (`basic_props:term/1`)

`+Definition` is any term. (`basic_props:term/1`)

`-Proto` is any term. (`basic_props:term/1`)

get_prototype_interface/2: PREDICATE

Usage: `get_prototype_interface(+Proto,-Interface)`

- *Description:* The predicate will return the interface from a proto structure.
- *Call and exit should be compatible with:*

`+Proto` is any term. (`basic_props:term/1`)

`-Interface` is any term. (`basic_props:term/1`)

get_prototype_definition/2: PREDICATE

Usage: `get_prototype_definition(+Proto,-Definition)`

- *Description:* The predicate will return the definition from a proto structure.
- *Call and exit should be compatible with:*

`+Proto` is any term.	(`basic_props:term/1`)
`-Definition` is any term.	(`basic_props:term/1`)

lookup_check_node/4: PREDICATE

No further documentation available for this predicate.

lookup_check_field/6: PREDICATE

No further documentation available for this predicate.

lookup_check_interface_fieldValue/8: PREDICATE

Usage: `lookup_check_interface_fieldValue(+ParseIn,-ParseOut,+AccessType,+FieldType,+Id,+FieldValue,DCGIn,DCGOut)`

- *Description:* The predicate formats the output for the interface part of the prototype. It also checks the values for the fields.
- *Call and exit should be compatible with:*

`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is an atom.	(`basic_props:atm/1`)
`+AccessType` is an atom.	(`basic_props:atm/1`)
`+FieldType` is any term.	(`basic_props:term/1`)
`+Id` is an atom.	(`basic_props:atm/1`)
`+FieldValue` is any term.	(`basic_props:term/1`)
`DCGIn` is a string (a list of character codes).	(`basic_props:string/1`)
`DCGOut` is a string (a list of character codes).	(`basic_props:string/1`)

lookup_field/4: PREDICATE

Usage: `lookup_field(+Parse,+FieldTypeId,+FieldId0,+FieldId1)`

- *Description:* The predicate will control that the two connected Fields are of the same type, e.g., SFColor - SFColor, MFVec3f - MFVec3f.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	(`internal_types:parse/1`)
`+FieldTypeId` is an atom.	(`basic_props:atm/1`)
`+FieldId0` is an atom.	(`basic_props:atm/1`)
`+FieldId1` is an atom.	(`basic_props:atm/1`)

lookup_route/5: PREDICATE

Usage: `lookup_route(+Parse,+NodeTypeId0,+FieldId0,+NodeTypeId1,+FieldId1)`

- *Description:* The predicate will check the routing behaviour for two given fields. They will be checked according to the binding rules, like name changes access proporties. The node types for the field must of course be given for the identification.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	`(internal_types:parse/1)`
`+NodeTypeId0` is an atom.	`(basic_props:atm/1)`
`+FieldId0` is an atom.	`(basic_props:atm/1)`
`+NodeTypeId1` is an atom.	`(basic_props:atm/1)`
`+FieldId1` is an atom.	`(basic_props:atm/1)`

lookup_fieldTypeId/1: PREDICATE

Usage: `lookup_fieldTypeId(+FieldTypeId)`

- *Description:* The predicate just make a check to see if the given FieldType id is among the allowed. You can not construct own ones and the check is mearly a spellcheck.
- *Call and exit should be compatible with:*

`+FieldTypeId` is an atom.	`(basic_props:atm/1)`

lookup_get_fieldType/4: PREDICATE

Usage: `lookup_get_fieldType(+Parse,+NodeTypeId,+fieldId,-FieldType)`

- *Description:* The predicate will return the given field's type. It will start the search in the ordinar dictionary and then to the personal dictionary sarting off with 'PROTO'. After it will go for 'DEF' and 'EXTERNPROTO'.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	`(internal_types:parse/1)`
`+NodeTypeId` is an atom.	`(basic_props:atm/1)`
`+fieldId` is an atom.	`(basic_props:atm/1)`
`-FieldType` is an atom.	`(basic_props:atm/1)`

lookup_field_access/4: PREDICATE

Usage: `lookup_field_access(+Parse,+NodenameId,+FieldId,+FieldId)`

- *Description:* The predicate will control that the access proporties are correct according to the certain rules that we have. It makes a check to see if the fields are of the same access type or if one of them is an exposedField. It is not doing a route check up to control that behaviour entirely.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	`(internal_types:parse/1)`
`+NodenameId` is an atom.	`(basic_props:atm/1)`
`+FieldId` is an atom.	`(basic_props:atm/1)`
`+FieldId` is an atom.	`(basic_props:atm/1)`

lookup_set_def/3: PREDICATE

Usage: `lookup_set_def(+Parse,+Name,+Node)`

- *Description:* The predicate will enter a new post in the personal dictionary for the node definition.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	(`internal_types:parse/1`)
`+Name` is an atom.	(`basic_props:atm/1`)
`+Node` is any term.	(`basic_props:term/1`)

lookup_set_prototype/4: PREDICATE

Usage: `lookup_set_prototype(+Parse,+Name,+Interface,+Definition)`

- *Description:* The predicate will insert the prototype definition in the personal dictionary and will give a warning if there is a multiple name given.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	(`internal_types:parse/1`)
`+Name` is an atom.	(`basic_props:atm/1`)
`+Interface` is any term.	(`basic_props:term/1`)
`+Definition` is any term.	(`basic_props:term/1`)

lookup_set_extern_prototype/4: PREDICATE

Usage: `lookup_set_extern_prototype(+Parse,+Name,+Interface,+Strings)`

- *Description:* The predicate will insert the external prototype definition in the personal dictionary and will give a warning if there is a multiple name given.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	(`internal_types:parse/1`)
`+Name` is an atom.	(`basic_props:atm/1`)
`+Interface` is any term.	(`basic_props:term/1`)
`+Strings` is any term.	(`basic_props:term/1`)

196 parser (library)

196.1 Usage and interface (parser)

- **Library usage:**
  `:- use_module(library(parser)).`
- **Exports:**
  - *Predicates:*
    `parser/2`, `nodeDeclaration/4`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `provrml/lookup`, `provrml/field_value`, `provrml/tokeniser`, `provrml/parser_util`, `provrml/possible`, `provrml/error`.

196.2 Documentation on exports (parser)

parser/2: PREDICATE

Usage: `parser(+VRML,-Terms)`

- *Description:* The parser uses a tokeniser to read the input text string of VRML code and returns a list with the corresponding terms. The tokens will be read in this parser as the grammar says. The parser is according to the specification of the VRML grammar, accept that it is performed over tokens in sted of the actual code.
- *Call and exit should be compatible with:*
  `+VRML` is a string (a list of character codes). (`basic_props:string/1`)
  `-Terms` is a list of `termss`. (`basic_props:list/2`)

nodeDeclaration/4: PREDICATE

No further documentation available for this predicate.

197 parser_util (library)

197.1 Usage and interface (parser_util)

- **Library usage:**
  `:- use_module(library(parser_util)).`
- **Exports:**
  - *Predicates:*
    `at_least_one/4`, `at_least_one/5`, `fillout/4`, `fillout/5`, `create_node/3`, `create_field/3`, `create_field/4`, `create_field/5`, `create_directed_field/5`, `correct_commenting/4`, `create_parse_structure/1`, `create_parse_structure/2`, `create_parse_structure/3`, `create_environment/4`, `insert_comments_in_beginning/3`, `get_environment_name/2`, `get_environment_type/2`, `get_row_number/2`, `add_environment_whitespace/3`, `get_indentation/2`, `inc_indentation/2`, `dec_indentation/2`, `add_indentation/3`, `reduce_indentation/3`, `push_whitespace/3`, `push_dictionaries/3`, `get_parsed/2`, `get_environment/2`, `inside_proto/1`, `get_dictionaries/2`, `strip_from_list/2`, `strip_from_term/2`, `strip_clean/2`, `strip_exposed/2`, `strip_restricted/2`, `strip_interface/2`, `set_parsed/3`, `set_environment/3`, `insert_parsed/3`, `reverse_parsed/2`, `stop_parse/2`, `look_first_parsed/2`, `get_first_parsed/3`, `remove_code/3`, `look_ahead/3`.
- **Other modules used:**
  - *System library modules:*
    `aggregates`, `dynamic`, `iso_misc`, `iso_byte_char`, `iso_incomplete`, `operators`, `read`, `write`, `lists`, `provrml/dictionary_tree`, `provrml/internal_types`.

197.2 Documentation on exports (parser_util)

at_least_one/4: PREDICATE

No further documentation available for this predicate.

at_least_one/5: PREDICATE

No further documentation available for this predicate.

fillout/4: PREDICATE

No further documentation available for this predicate.

fillout/5: PREDICATE

No further documentation available for this predicate.

create_node/3: PREDICATE

Usage: `create_node(+NodeTypeId,+Parse,-Node)`

- *Description:* The predicate will construct a node term with the read guts which is inside the parse structure. A node consists of its name and one argument, a list of its fields.
- *Call and exit should be compatible with:*

`+NodeTypeId` is an atom.	(`basic_props:atm/1`)
`+Parse` is a parse structure.	(`internal_types:parse/1`)
`-Node` is any term.	(`basic_props:term/1`)

create_field/3: PREDICATE

Usage: `create_field(+FieldNameId,+Arguments,-Field)`

- *Description:* The predicate will construct a field with the Id as the fieldname and the arguments as they are, in a double list, which results in a single list or a single list which will result in free arguments.
- *Call and exit should be compatible with:*

`+FieldNameId` is an atom.	(`basic_props:atm/1`)
`+Arguments` is any term.	(`basic_props:term/1`)
`-Field` is any term.	(`basic_props:term/1`)

create_field/4: PREDICATE

Usage: `create_field(+FieldAccess,+FieldType,+FieldId,-Field)`

- *Description:* The predicate will construct a field with its access type as the name with type and id as arguments.
- *Call and exit should be compatible with:*

`+FieldAccess` is an atom.	(`basic_props:atm/1`)
`+FieldType` is an atom.	(`basic_props:atm/1`)
`+FieldId` is an atom.	(`basic_props:atm/1`)
`-Field` is any term.	(`basic_props:term/1`)

create_field/5: PREDICATE

Usage: `create_field(+FieldAccess,+FieldType,+FieldId,+Fieldvalue,-Field)`

- *Description:* The predicate will construct a field with its access type as the name with type, id and value as arguments.
- *Call and exit should be compatible with:*

`+FieldAccess` is an atom.	(`basic_props:atm/1`)
`+FieldType` is an atom.	(`basic_props:atm/1`)
`+FieldId` is an atom.	(`basic_props:atm/1`)
`+Fieldvalue` is any term.	(`basic_props:term/1`)
`-Field` is any term.	(`basic_props:term/1`)

create_directed_field/5: PREDICATE

Usage: `create_directed_field(+Access,+Type,+Id0,+Id1,-Field)`

- *Description:* The predicate will construct a directed field with the key word IS in the middle. Its access type as the name with type, from id0 and to id1 as arguments.
- *Call and exit should be compatible with:*

`+Access` is an atom.	(`basic_props:atm/1`)
`+Type` is an atom.	(`basic_props:atm/1`)
`+Id0` is an atom.	(`basic_props:atm/1`)
`+Id1` is an atom.	(`basic_props:atm/1`)
`-Field` is any term.	(`basic_props:term/1`)

correct_commenting/4: PREDICATE

Usage: `correct_commenting(+Place,+Comment,+ParsedIn,-ParsedOut)`

- *Description:* The predicate places the comment 'before' or 'after' the parsed term. This results in a list with the term and the comment or in just returning the term.
- *Call and exit should be compatible with:*

`+Place` is an atom.	(`basic_props:atm/1`)
`undefined:str(+Comment)`	(undefined property)
`+ParsedIn` is any term.	(`basic_props:term/1`)
`-ParsedOut` is any term.	(`basic_props:term/1`)

create_parse_structure/1: PREDICATE

Usage: `create_parse_structure(-Parse)`

- *Description:* The predicate will construct the parse structure with its three fields: the parsing list, the environment structure, and the dictionaries.
- *Call and exit should be compatible with:*

`-Parse` is a parse structure.	(`internal_types:parse/1`)

create_parse_structure/2: PREDICATE

Usage 1: `create_parse_structure(+ParseIn,-ParseOut)`

- *Description:* The predicate will construct a parse structure with its three fields: the parsing list, the environment structure, and the dictionaries. It will reuse the environment and the dictionaries from the input.
- *Call and exit should be compatible with:*

`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

Usage 2: `create_parse_structure(+ParsedList,-ParseOut)`

- *Description:* The predicate will construct a parse structure with its three fields: the parsing list, the environment structure, and the dictionaries. It will use the list of parsed items in its structure.
- *Call and exit should be compatible with:*

`+ParsedList` is a list of `terms`.	(`basic_props:list/2`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

create_parse_structure/3: PREDICATE

Usage: `create_parse_structure(+ParsedList,+ParseIn,-ParseOut)`

- *Description:* The predicate will construct a parse structure with its three fields: the parsing list, the environment structure, and the dictionaries. It will use the list of parsed items in its structure and the environment and the dictionary from the parse structure given.
- *Call and exit should be compatible with:*

`+ParsedList` is a list of `terms`.	(`basic_props:list/2`)
`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

create_environment/4: PREDICATE

Usage: `create_environment(+Parse,+EnvType,+Name,-EnvStruct)`

- *Description:* The predicate will construct an environment structure based on the information in the parse structure. Well only the white- space information will be reused. The are three types of environments 'PROTO', 'EXTERNPROTO', and 'DEF'.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	(`internal_types:parse/1`)
`+EnvType` is an atom.	(`basic_props:atm/1`)
`+Name` is an atom.	(`basic_props:atm/1`)
`-EnvStruct` is an environment structure.	(`internal_types:environment/1`)

insert_comments_in_beginning/3: PREDICATE

Usage: `insert_comments_in_beginning(+Comment,+ParseIn,-ParseOut)`

- *Description:* We add the comment in the beginneing of the parsed, to get the proper look.
- *Call and exit should be compatible with:*

`undefined:str(+Comment)`	(undefined property)
`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

get_environment_name/2: PREDICATE

Usage: `get_environment_name(+Environment,-Name)`

- *Description:* The predicate will return the enviroment name.
- *Call and exit should be compatible with:*

`+Environment` is an environment structure.	(`internal_types:environment/1`)
`-Name` is an atom.	(`basic_props:atm/1`)

get_environment_type/2: PREDICATE

Usage: `get_environment_type(+Environment,-Type)`

– *Description:* The predicate will return the enviroment type, one of the three: 'PROTO', 'EXTERNPROTO', and 'DEF'.
– *Call and exit should be compatible with:*

`+Environment` is an environment structure. (`internal_types:environment/1`)
`-Type` is an atom. (`basic_props:atm/1`)

get_row_number/2: PREDICATE

Usage: `get_row_number(+Parse,-Row)`

– *Description:* The predicate will return the row number from the parse structure. The row number is not fully implemented.
– *Call and exit should be compatible with:*

`+Parse` is a parse structure. (`internal_types:parse/1`)
`-Row` is a number. (`basic_props:num/1`)

add_environment_whitespace/3: PREDICATE

Usage: `add_environment_whitespace(+EnvIn,+WhiteSpaceList,-EnvOut)`

– *Description:* The predicate will add the new whitespace that is collected in a list of whitespaces to the environment.
– *Call and exit should be compatible with:*

`+EnvIn` is an environment structure. (`internal_types:environment/1`)
`+WhiteSpaceList` is a list of `atm`s. (`basic_props:list/2`)
`-EnvOut` is an environment structure. (`internal_types:environment/1`)

get_indentation/2: PREDICATE

Usage 1: `get_indentation(+Whitespace,-Indentation)`

– *Description:* The predicate will return the indentation depth from a whitespace structure.
– *Call and exit should be compatible with:*

`+Whitespace` is a whitespace structure. (`internal_types:whitespace/1`)
`-Indentation` is a number. (`basic_props:num/1`)

Usage 2: `get_indentation(+Parse,-Indentation)`

– *Description:* The predicate will return the indentation depth from a parse structure.
– *Call and exit should be compatible with:*

`+Parse` is a parse structure. (`internal_types:parse/1`)
`-Indentation` is a number. (`basic_props:num/1`)

inc_indentation/2: PREDICATE

Usage: `inc_indentation(+ParseIn,-ParseOut)`

– *Description:* Will increase the indentation with one step to a parse structure.
– *Call and exit should be compatible with:*

`+ParseIn` is a parse structure. (`internal_types:parse/1`)
`-ParseOut` is a parse structure. (`internal_types:parse/1`)

dec_indentation/2: PREDICATE

Usage: `dec_indentation(+ParseIn,-ParseOut)`

- *Description:* Will decrease the indentation with one step to a parse structure.
- *Call and exit should be compatible with:*

`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

add_indentation/3: PREDICATE

No further documentation available for this predicate.

reduce_indentation/3: PREDICATE

No further documentation available for this predicate.

push_whitespace/3: PREDICATE

Usage: `push_whitespace(+ParseWithWhitespace,+ParseIn,-ParseOut)`

- *Description:* The predicate will add the whitespace values from one parse structure to another one, resultin in the output, with the values from the second parse structure with the whitespace from the first added.
- *Call and exit should be compatible with:*

`+ParseWithWhitespace` is a parse structure.	(`internal_types:parse/1`)
`+ParseIn` is a parse structure.	(`internal_types:parse/1`)
`-ParseOut` is a parse structure.	(`internal_types:parse/1`)

push_dictionaries/3: PREDICATE

Usage: `push_dictionaries(+Parse,+Parse,-Parse)`

- *Description:* The predicate will set the first parse structure's directory to the second parsing structure argument. The resulting parsing structure will be returned.
- *Call and exit should be compatible with:*

`+Parse` is a parse structure.	(`internal_types:parse/1`)
`+Parse` is a parse structure.	(`internal_types:parse/1`)
`-Parse` is a parse structure.	(`internal_types:parse/1`)

get_parsed/2: PREDICATE

Usage 1: `get_parsed(+ParseStructure,-ListOfParsed)`

- *Description:* The predicate will return a list of the parsed terms that is inside the parse structure.
- *Call and exit should be compatible with:*

`+ParseStructure` is a parse structure.	(`internal_types:parse/1`)
`-ListOfParsed` is a list of `terms`.	(`basic_props:list/2`)

Usage 2: `get_parsed(+ParseStructure,-EnvironmentStructure)`

– *Description:* The predicate will return the environment of the parse structure.
– *Call and exit should be compatible with:*

`+ParseStructure` is a parse structure. (`internal_types:parse/1`)

`-EnvironmentStructure` is an environment structure. (`internal_types:environment/1`)

Usage 3: `get_parsed(+ParseStructure,-Dictionaries)`

– *Description:* The predicate will return dictionary used within the parse structure.
– *Call and exit should be compatible with:*

`+ParseStructure` is a parse structure. (`internal_types:parse/1`)

`-Dictionaries` is a dictionary. (`internal_types:dictionary/1`)

get_environment/2: PREDICATE

No further documentation available for this predicate.

inside_proto/1: PREDICATE

Usage: `inside_proto(+Parse)`

– *Description:* The predicate will answer to the question: are we parsing inside a PROTO/EXTERNPROTO.
– *Call and exit should be compatible with:*

`+Parse` is a parse structure. (`internal_types:parse/1`)

get_dictionaries/2: PREDICATE

No further documentation available for this predicate.

strip_from_list/2: PREDICATE

Usage: `strip_from_list(+ListWithComments,-CleanList)`

– *Description:* The predicate will strip the list from comments and return a list without any comments.
– *Call and exit should be compatible with:*

`+ListWithComments` is a list of `terms`. (`basic_props:list/2`)

`-CleanList` is a list of `terms`. (`basic_props:list/2`)

strip_from_term/2: PREDICATE

Usage: `strip_from_term(+Term,-Stripped)`

– *Description:* The predicate will remove comments from a term, it will reduce its arguments if there are comments as arguments.
– *Call and exit should be compatible with:*

`+Term` is any term. (`basic_props:term/1`)

`-Stripped` is any term. (`basic_props:term/1`)

strip_clean/2: PREDICATE

Usage: `strip_clean(+ParsedIn,-ParsedOut)`

- *Description:* The predicate will return a striped list or a single atom if there was no comments and no more items in the list. It will also return a atom if there is comments and only one other element.
- *Call and exit should be compatible with:*

  `+ParsedIn` is any term. (`basic_props:term/1`)

  `-ParsedOut` is any term. (`basic_props:term/1`)

strip_exposed/2: PREDICATE

No further documentation available for this predicate.

strip_restricted/2: PREDICATE

No further documentation available for this predicate.

strip_interface/2: PREDICATE

Usage: `strip_interface(+Interface,-StrippedInterface)`

- *Description:* The predicate will remove comments from the interface that we read for the PROTOtype. This will help us when setting the properties.
- *Call and exit should be compatible with:*

  `+Interface` is a list of `terms`. (`basic_props:list/2`)

  `-StrippedInterface` is a list of `terms`. (`basic_props:list/2`)

set_parsed/3: PREDICATE

Usage: `set_parsed(+ParseIn,+NewParseList,-ParseOut)`

- *Description:* The predicate will create a new parse structure from the first parse structure with the parse list from the second argument.
- *Call and exit should be compatible with:*

  `+ParseIn` is a parse structure. (`internal_types:parse/1`)

  `+NewParseList` is a list of `terms`. (`basic_props:list/2`)

  `-ParseOut` is a parse structure. (`internal_types:parse/1`)

set_environment/3: PREDICATE

Usage: `set_environment(+Environment,+ParseIn,-ParseOut)`

- *Description:* The modificator will return a parse structure with the environment given with the other properties from the first parse structure.
- *Call and exit should be compatible with:*

  `+Environment` is an environment structure. (`internal_types:environment/1`)

  `+ParseIn` is a parse structure. (`internal_types:parse/1`)

  `-ParseOut` is a parse structure. (`internal_types:parse/1`)

insert_parsed/3: PREDICATE

No further documentation available for this predicate.

reverse_parsed/2: PREDICATE

No further documentation available for this predicate.

stop_parse/2: PREDICATE

Usage: `stop_parse(+TermIn,-TermOut)`

- *Description:* The predicate will bind the invalue to the outvalue, used to terminate a parsing.
- *Call and exit should be compatible with:*

  `+TermIn` is any term. (`basic_props:term/1`)

  `-TermOut` is any term. (`basic_props:term/1`)

look_first_parsed/2: PREDICATE

Usage: `look_first_parsed(+Parse,-First)`

- *Description:* Look at the first item in the parse structure.
- *Call and exit should be compatible with:*

  `+Parse` is a parse structure. (`internal_types:parse/1`)

  `-First` is any term. (`basic_props:term/1`)

get_first_parsed/3: PREDICATE

Usage: `get_first_parsed(+ParseIn,-ParseOut,-First)`

- *Description:* Get the first item in the parse structure and return the parse structure with the item removed.
- *Call and exit should be compatible with:*

  `+ParseIn` is a parse structure. (`internal_types:parse/1`)

  `-ParseOut` is a parse structure. (`internal_types:parse/1`)

  `-First` is any term. (`basic_props:term/1`)

remove_code/3: PREDICATE

No further documentation available for this predicate.

look_ahead/3: PREDICATE

Usage: `look_ahead(+Name,+Parsed,-Parsed)`

- *Description:* This predicate is used normally by the CDG and the two last arguments will therefore be the same because we don't remove the parsed. The name is the name inside a term, the first argument.
- *Call and exit should be compatible with:*

  `+Name` is an atom. (`basic_props:atm/1`)

  `+Parsed` is a list of `terms`. (`basic_props:list/2`)

  `-Parsed` is a list of `terms`. (`basic_props:list/2`)

198 possible (library)

Version: 0.1 (1999/2/19, 6:32:46 MET)

198.1 Usage and interface (possible)

- **Library usage:**
  `:- use_module(library(possible)).`
- **Exports:**
  - *Predicates:*
    `continue/3`.
- **Other modules used:**
  - *System library modules:*
    `lists`.

198.2 Documentation on exports (possible)

continue/3: PREDICATE

No further documentation available for this predicate.

199 tokeniser (library)

Version: 1.7#171 (2002/1/3, 18:20:29 CET)

199.1 Usage and interface (tokeniser)

- **Library usage:**
  `:- use_module(library(tokeniser)).`
- **Exports:**
  - *Predicates:*
    `tokeniser/2`, `token_read/3`.
- **Other modules used:**
  - *System library modules:*
    `iso_byte_char`, `lists`, `write`, `provrml/error`.

199.2 Documentation on exports (tokeniser)

tokeniser/2: PREDICATE

Usage: `tokeniser(+VRML,-Tokens)`

- *Description:* This predicate will perform the parsing of the VRML code. The result will be tokens that will be the source for producing the Prolog terms of the VRML code. This is done in the parser module. From these terms analysis, changing, and any thing that you want to do with VRML code from Prolog programming language. We perform the predicate with a catch call to be able to output error messages if encountered.
- *Call and exit should be compatible with:*
  `+VRML` is a list of `atm`s. (`basic_props:list/2`)
  `-Tokens` is a list of `term`s. (`basic_props:list/2`)

token_read/3: PREDICATE

No further documentation available for this predicate.

PART XII - Appendices

These appendices describe the installation of the Ciao environment on different systems and some other issues such as reporting bugs, signing up on the Ciao user's mailing list, downloading new versions, limitations, etc.

200 Installing Ciao from the source distribution

Author(s): Manuel Carro, Daniel Cabeza, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.7#130 (2001/10/28, 17:6:47 CET)

This describes the installation procedure for the Ciao Prolog system, including libraries and manuals, from a *source* distribution. This applies primarily to Unix-type systems (Linux, Mac OS X, Solaris, SunOS, etc.). However, the sources can also be compiled on Windows NT/95/98 systems – see Section 200.6 [Installation and compilation under Windows], page 740 for details.

If you find any problems during installation, please refer to Section 200.8 [Troubleshooting (nasty messages and nifty workarounds)], page 742. See also Section 202.3 [Downloading new versions], page 749 and Section 202.4 [Reporting bugs], page 750.

200.1 Un*x installation summary

Note: it is recommended that you read the full installation instructions (specially if the installation will be shared by different architectures). However, in many cases it suffices to follow this summary:

1. Uncompress and unpackage (using `gunzip` and `tar -xpf`) the distribution. This will put everything in a new directory whose name reflects the Ciao version.
2. Enter the newly created directory (`SRC`). Edit `SETTINGS` and check/set the variables `SRC`, `BINROOT` (where the executables will go), `LIBROOT` (where the libraries will go), and `DOCROOT` (where the documentation will go, preferably a directory *accessible via* WWW).
3. Type `gmake install`. This will build executables, compile libraries, and install everything in a directory `LIBROOT/ciao` and in `BINROOT`.

   Note that `gmake` refers to the GNU implementation of the make Un*x command, which is available in many systems (including all Linux systems and Mac OS X) simply as `make`. I.e., you can try simply typing `make install` if `gmake install` does not work. If typing `make` stops right away with error messages it is probably an older version and you need to install `gmake`.
4. Make the following modifications in your startup scripts. This will make the documentation accessible, set the correct mode when opening Ciao source files in `emacs`, etc. Note that `<LIBROOT>` must be replaced with the appropriate value:
   - For users a *csh-compatible shell* (`csh`, `tcsh`, ...), add to `~/.cshrc`:

     ```
     if ( -e <LIBROOT>/ciao/DOTcshrc ) then
        source <LIBROOT>/ciao/DOTcshrc
     endif
     ```

     `Mac OS X` users should add (or modify) the `path` file in the directory `~/Library/init/tcsh`, adding the lines shown above. **Note:** while this is recognized by the terminal shell, and therefore by the text-mode Emacs which comes with Mac OS X, the Aqua native Emacs 21 does not recognize that initialization. It is thus necessary, at this moment, to set manually the Ciao shell (ciaosh) and Ciao library location by hand. This can be done from the Ciao menu within Emacs after a Ciao Prolog file has been loaded. We suppose that the reason is that Mac OS X does not actually consult the per-user initialization files on startup. It should also be possible to put the right initializations in the .emacs file using the `setenv` function of Emacs-lisp, as in

     ```
     (setenv "CIAOLIB" "<LIBROOT>/ciao")
     ```

     The same can be done for the rest of the variables initialized in `<LIBROOT>/ciao/DOTcshrc`
   - For users of an *sh-compatible shell* (`sh`, `bash`, ...), add to `~/.profile`:

```
if [ -f <LIBROOT>/ciao/DOTprofile ]; then
   . <LIBROOT>/ciao/DOTprofile
fi
```

This will set up things so that the Ciao executables are found and you can access the Ciao system manuals using the `info` command. Note that, depending on your shell, *you may have to log out and back in* for the changes to take effect.

- Also, if you use `emacs` (highly recommended) add this line to your `~/.emacs` file:

```
(load-file "<LIBROOT>/ciao/DOTemacs.el")
```

If you are installing Ciao globally in a multi-user machine, make sure that you instruct all users to do the same. If you are the system administrator, the previous steps can be done once and for all, and globally for all users by including the lines above in the central startup scripts (e.g., in Linux `/etc/bashrc`, `/etc/csh.login`, `/etc/csh.cshrc`, `/etc/skel`, `/usr/share/emacs/.../lisp/site-init.pl`, etc.).

5. Finally, if the (freely available) `emacs` editor/environment is not installed in your system, we *highly recommend* that you also install it at this point (see Section 200.2 [Un*x full installation instructions], page 736 for instructions). While it is easy to use Ciao with any editor of your choice, the Ciao distribution includes a very powerful *application development environment* which is based on `emacs` and which enables, e.g., source-level debugging, syntax coloring, context-sensitive on-line help, etc.
6. You may want now want to check your installation (see Section 200.3 [Checking for correct installation on Un*x], page 739) and read the documentation, which is stored in `DOCROOT` (copied from `SRC/doc/reference`) and can be easily accessed as explained in that same section. There are special "getting started" sections at the beginning of the manual.
7. If you have any problems you may want to check the rest of the instructions. The system can be *uninstalled* by typing `gmake uninstall`.

200.2 Un*x full installation instructions

1. **Uncompress and unpackage:** (using `gunzip` and `tar -xpf`) the distribution in a suitable directory. This will create a new directory called `ciao-X.Y`, where `X.Y` is the version number of the distribution. The `-p` option in the `tar` command ensures that the relative dates of the files in the package are preserved, which is needed for correct operation of the Makefiles.
2. **Select installation options:** Edit the file `SETTINGS` and set the following variables:
   - `SRC`: directory where the sources are stored.
   - `BINROOT`: directory where the Ciao executables will go. For example, if `BINROOT=/usr/local/bin`, then the Ciao compiler (`ciaoc`) will be stored at `/usr/local/bin/ciaoc`. Actually, it will be a link to `ciaoc-`*VersionNumber*. This applies also to other executables below and is done so that several versions of Ciao can coexist on the same machine. Note that the *version installed latest* will be the one started by default when typing `ciao`, `ciaoc`, etc.
   - `LIBROOT`: directory where the run-time libraries will be installed. The Ciao installation procedure will create a new subdirectory `ciao` below `LIBROOT` and a subdirectory below this one for each Ciao version installed. For example, if `LIBROOT=/usr/local/lib` and you have Ciao version `x.y`, then the libraries will be installed under `/usr/local/lib/ciao/ciao-x.y`. This allows you to install site-specific programs under `/usr/local/lib/ciao` and they will not be overwritten if a new version of Ciao is installed. It also again allows having several Ciao versions installed simultaneously.

- `DOCROOT`: directory where the manuals will be installed. It is often convenient if this directory is accessible via WWW (`DOCROOT=/home/httpd/html/ciao`, or something like that).

For network-based installations, it is of *utmost importance* that the paths given be reachable in all the networked machines. Different machines with different architectures can share the same physical `SRC` directory during installation, since compilations for different architectures take place in dedicated subdirectories. Also, different machines/architectures can share the same `LIBROOT` directory. This saves space since the architecture-independent libraries will be shared. See Section 200.5 [Multiarchitecture support], page 740 below.

3. **Compile Ciao:** At the ciao top level directory type `gmake all`.

   Important: use GNU make (`gmake`), not the standard UNIX make, as the latter does not support some features used during the compilation. It does not matter if the name of the executable is `make` or `gmake`: only make sure that it is GNU make.

   This will:

   - Build an engine in `$(SRC)/bin/$(CIAOARCH)`, where `$(CIAOARCH)` depends on the architecture. The engine is the actual interpreter of the low level code into which Ciao Prolog programs are compiled.
   - Build a new Ciao standalone compiler (`ciaoc`), with the default paths set for your local configuration (nonetheless, these can be overridden by environment variables, as described below).
   - Precompile all the libraries under `$(SRC)/lib` and `$(SRC)/library` using this compiler.
   - Compile a toplevel Prolog shell and a shell for Prolog scripts, under the `$(SRC)/shell` directory.
   - Compile some small, auxiliary applications (contained in the `etc` directory, and documented in the part of the manual on 'Miscellaneous Standalone Utilities').

   This step can be repeated successively for several architectures in the same source directory. Only the engine and some small parts of the libraries (those written in C) differ from one architecture to the other. Standard Ciao Prolog code compiles into bytecode object files (`.po`) and/or executables which are portable among machines of different architecture, provided there is an executable engine accessible in every such machine. See more details below under Section 200.5 [Multiarchitecture support], page 740.

4. **Check compilation:** If the above steps have been satisfactorily finished, the compiler has compiled itself and all the distribution modules, and very probably everything is fine.
5. **Install Ciao:** To install Ciao in the directories selected in the file `SETTINGS` during step 2 above, type `gmake justinstall`. This will:

   - Install the executables of the Ciao program development tools (i.e., the general driver/top-level `ciao`, the standalone compiler `ciaoc`, the script interpreter `ciao-shell`, miscellaneous utilities, etc.) in `BINROOT` (see below). In order to use these tools, the `PATH` environment variable of users needs to contain the path `BINROOT`.
   - Install the Ciao libraries under `LIBROOT/ciao` (these will be automatically found).
   - Install under `DOCROOT` the Ciao manuals in several formats (such as GNU `info`, `html`, `postscript`, etc.), depending on the distribution. In order for these manuals to be found when typing `M-x info` within `emacs`, or by the standalone `info` and `man` commands, the `MANPATH` and `INFOPATH` environment variables of users both need to contain the path `DOCROOT`.
   - Install under `LIBROOT/ciao` the Ciao GNU `emacs` interface (`ciao.el`, which provides an interactive interface to the Ciao program development tools, as well as some other auxiliary files) and a file `DOTemacs` containing the `emacs` initialization commands which are needed in order to use the Ciao `emacs` interface.

6. **Set up user environments:** In order to automate the process of setting the variables above, the installation process leaves the files `LIBROOT/ciao/DOTcshrc` (for `csh`-like shells), `LIBROOT/ciao/DOTprofile` (for `sh`-like shells), and `LIBROOT/ciao/DOTemacs` (for emacs) with appropriate definitions which will take care of all needed environment variable definitions and emacs mode setup. Make the following modifications in your startup scripts, so that these files are used (`<LIBROOT>` must be replaced with the appropriate value):

   - For users a *csh-compatible shell* (`csh`, `tcsh`, ...), add to `~/.cshrc`:

     ```
     if ( -e <LIBROOT>/ciao/DOTcshrc ) then
        source <LIBROOT>/ciao/DOTcshrc
     endif
     ```

     `Mac OS X` users should add (or modify) the `path` file in the directory `~/Library/init/tcsh`, adding the lines shown above. **Note:** while this is recognized by the terminal shell, and therefore by the text-mode Emacs which comes with Mac OS X, the Aqua native Emacs 21 does not recognize that initialization. It is thus necessary, at this moment, to set manually the Ciao shell (ciaosh) and Ciao library location by hand. This can be done from the Ciao menu within Emacs after a Ciao Prolog file has been loaded. We suppose that the reason is that Mac OS X does not actually consult the per-user initialization files on startup. It should also be possible to put the right initializations in the .emacs file using the `setenv` function of Emacs-lisp, as in

     ```
     (setenv "CIAOLIB" "<LIBROOT>/ciao")
     ```

     The same can be done for the rest of the variables initialized in `<LIBROOT>/ciao/DOTcshrc`

   - For users of an *sh-compatible shell* (`sh`, `bash`, ...), add to `~/.profile`:

     ```
     if [ -f <LIBROOT>/ciao/DOTprofile ]; then
        . <LIBROOT>/ciao/DOTprofile
     fi
     ```

     This will set up things so that the Ciao executables are found and you can access the Ciao system manuals using the `info` command. Note that, depending on your shell, *you may have to log out and back in* for the changes to take effect.

   - Also, if you use `emacs` (highly recommended) add this line to your `~/.emacs` file:

     ```
     (load-file "<LIBROOT>/ciao/DOTemacs.el")
     ```

   If you are installing Ciao globally in a multi-user machine, make sure that you instruct all users to do the same. If you are the system administrator, the previous steps can be done once and for all, and globally for all users by including the lines above in the central startup scripts (e.g., in Linux `/etc/bashrc`, `/etc/csh.login`, `/etc/csh.cshrc`, `/etc/skel`, `/usr/share/emacs/.../lisp/site-init.pl`, etc.).

7. **Download and install Emacs (highly recommended):** If the (freely available) `emacs` editor is not installed in your system, its installation is *highly recommended* (if you are installing in a multi-user machine, you may want to do it in a general area so that it is available for other users, even if you do not use it yourself). While it is easy to use Ciao with any editor of your choice, the Ciao distribution includes a very powerful *application development environment* which is based on `emacs` and which enables, e.g., source-level debugging, syntax coloring, context-sensitive on-line help, etc.

   The emacs editor (in all its versions: Un*x, Windows, etc.) can be downloaded from, for example, `http://www.emacs.org/`, and also from the many GNU mirror sites worldwide (See `http://www.gnu.org/` for a list), in the `gnu/emacs` and `gnu/windows/emacs` directories. You can find answers to frequently asked questions (FAQ) about `emacs` in general at `http://www.gnu.org/software/emacs/emacs-faq.text` and about the Windows version at `http://www.gnu.org/software/emacs/windows/ntemacs.html` (despite the `ntemacs` name it runs fine also as is on Win9X and Win2000 machines).

8. **Check installation / read documentation:** You may now want to check your installation (see Section 200.3 [Checking for correct installation on Un*x], page 739) and read the documentation, which is stored in `DOCROOT` (copied from `SRC/doc/reference`) and can be easily accessed as explained that same section. There are special "getting started" sections at the beginning of the manual.

Other useful `make` targets are listed at the beginning of `$(SRC)/Makefile`.

If you have any problems you may want to check Section 200.8 [Troubleshooting (nasty messages and nifty workarounds)], page 742.

The system can be *uninstalled* by typing `gmake uninstall` in the top directory (the variables in `SETTINGS` should have the same value as when the install was performed, so that the same directories are cleaned).

200.3 Checking for correct installation on Un*x

If everything has gone well, several applications and tools should be available to a normal user. Try the following while logged in as a *normal user* (important in order to check that permissions are set up correctly):

- Typing `ciao` (or `ciaosh`) should start the typical Prolog top-level shell.
- In the top-level shell, Prolog library modules should load correctly. Type for example `use_module(library(dec10_io))` –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.
- Typing `ciaoc` should produce the help message from the Ciao standalone compiler.
- Typing `ciao-shell` should produce a message saying that no code was found. This is a Ciao application which can be used to write scripts written in Prolog, i.e., files which do not need any explicit compilation to be run.

Also, the following documentation-related actions should work:

- If the `info` program is installed, typing `info` should produce a list of manuals which *should include Ciao manual(s) in a separate area* (you may need to log out and back in so that your shell variables are reinitialized for this to work).
- Opening with a WWW browser (e.g., `netscape`) the directory or `URL` corresponding to the `DOCROOT` setting should show a series of Ciao-related manuals. Note that *style sheets* should be activated for correct formatting of the manual.
- Typing `man ciao` should produce a man page with some very basic general information on Ciao (and pointing to the on-line manuals).
- The `DOCROOT` directory should contain the manual also in the other formats such as `postscript` or `pdf` which specially useful for printing. See Section 2.3.7 [Printing manuals (Un*x)], page 20 for instructions.

Finally, if `emacs` is installed, after starting it (typing `emacs`) the following should work:

- Typing ⟨^H⟩ ⟨i⟩ (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
- When opening a Prolog file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
- Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ ⟨l⟩) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

200.4 Cleaning up the source directory

After installation, the source directory can be cleaned up in several ways:

- `gmake uninstall` removes the installation but does not touch the source directories.
- `gmake totalclean` leaves the distribution is its original form, throwing away any intermediate files (as well as any unneeded files left behind by the Ciao developers), while still allowing recompilation.

Other useful `make` targets are listed at the beginning of `$(SRC)/Makefile`.

200.5 Multiarchitecture support

As mentioned before, Ciao applications (including the compiler and the top level) can run on several machines with different architectures without any need for recompiling, provided there is one Ciao engine (compiled for the corresponding architecture) accessible in each machine. Also, the Ciao libraries (installed in `LIBROOT`, which contain also the engines) and the actual binaries (installed in `BINROOT`) can themselves be shared on several machines with different architectures, saving disk space.

For example, assume that the compiler is installed as:

`/usr/local/share/bin/ciaoc`

and the libraries are installed under

`/usr/local/share/lib`

Assume also that the `/usr/local/share` directory is mounted on, say, a number of Linux and a number of Solaris boxes. In order for `ciaoc` to run correctly on both types of machines, the following is needed:

1. Make sure you that have done `gmake install` on one machine of each architecture (once for Linux and once for Solaris in our example). This recompiles and installs a new engine and any architecture-dependent parts of the libraries for each architecture. The engines will have names such as `ciaoengine.LINUXi86`, `ciaoengine.SolarisSparc`, and so on.
2. In multi-architecture environments it is even more important to make sure that users make the modifications to their startup scripts using `<LIBROOT>/ciao/DOTcshrc` etc. The selection of the engine (and architecture-dependent parts of libraries) is done in these scripts by setting the environment variable `CIAOARCH`, using the `ciao_get_arch` command, which is installed automatically when installing Ciao. This will set `CIAOARCH` to, say, `LINUXi86`, `SolarisSparc`, respectively, and `CIAOENGINE` will be set to `ciaoengine.`*CIAOARCH*.

   However, note that this is not strictly necessary if running on only one architecture: if `CIAOARCH` is not set (i.e., undefined), the Ciao executables will look simply for `ciaoengine`, which is always a link to the latest engine installed in the libraries. But including the initialization files provided has the advantage of setting also paths for the manuals, etc.

200.6 Installation and compilation under Windows

There are two possibilities in order to install Ciao Prolog on Windows NT/95/98 machines:

- Installing from the Windows *precompiled* distribution. This is the easiest since it requires no compilation and is highly recommended. This is described in Chapter 201 [Installing Ciao from a Win32 binary distribution], page 745.
- Installing the standard Ciao Prolog (Un*x) system source distribution and compiling it under Windows. This is somewhat more complex and currently requires the (freely available) Cygnus Win32 development libraries –described below.

In order to compile Ciao Prolog for Win32 environments you need to have the (public domain) *Cygnus Win32* and development libraries installed in your system. Compilation should be performed preferably under Windows NT.

- Thus, the first step, if Cygnus Win32 is not installed in your system, is to download it (from, e.g., `http://www.cygnus.com/misc/gnu-win32`) and install it. The compilation process also requires that the executables `rm.exe`, `sh.exe`, and `uname.exe` from the Cygnus distribution be copied under `/bin` prior to starting the process (if these executables are not available under `/bin` the compilation process will produce a number of errors and eventually stop prematurely).
- Assuming all of the above is installed, type `make allwin32`. This will compile both the engine and the Prolog libraries. In this process, system libraries that are normally linked dynamically under Un*x (i.e., those for which `.so` dynamically loadable files are generated) are linked statically into the engine (this is done instead of generating `.dll`s because of a limitation in the current version of the Cygnus Win32 environment). No actual installation is made at this point, i.e., this process leaves things in a similar state as if you had just downloaded and uncompressed the precompiled distribution. Thus, in order to complete the installation you should now:
- Follow now the instructions in Chapter 201 [Installing Ciao from a Win32 binary distribution], page 745.

A further note regarding the executables generated by the Ciao compiler and top-level: the same considerations given in Chapter 201 [Installing Ciao from a Win32 binary distribution], page 745 apply regarding `.bat` files, etc. However, in a system in which Cygnus Win32 is installed these executables can also be used in a very simple way. In fact, the executables can be run as in Un*x by simply typing their name at the `bash` shell command line without any associated `.bat` files. This only requires that the `bash` shell which comes with Cygnus Win32 be installed and accessible: simply, make sure that `/bin/sh.exe` exists.

200.7 Porting to currently unsupported operating systems

If you would like to port Ciao to a currently unsupported platform, there are several issues to take into account. The main one is to get the *engine* to compile in that platform, i.e., the C code under the `engine` directory. The procedure currently followed by Ciao to decide the various flags needed to compile is as follows:

- The shell script `$(SRC)/etc/ciao_get_arch` is executed; it returns a string describing the operating system and the processor architecture (e.g., LINUXi86, SolarisSparc, SolarisAlpha, etc.). You should make sure it returns a correct (and meaningful) string for your setup. This string is used trhoughout the compilation to create several architecture-dependant flags.
- In the directory `$(SRC)/makefile-sysdep` there are files called mkf-<OS><ARCH> for every combination of operating system and architecture in which Ciao is know to (and how to) compile. They set several flags regarding, for example, whether to use or not threads, which threads library to use, the optimization flags to use, the compiler, linker, and it also sets separately the architecture name (ARCHNAME variable) and the operating system (OSNAME). You should create a new mkf file for your machine, starting from the one which is closest to you.
- Most times the porting problems happen in the use of locks and threads. You can either disable them, or have a look at the files `$(SRC)/engine/locks.h` and `$(SRC)/engine/threads.h`. If you know how to implement native (assembler) locks for your architecture, enable HAVE_NATIVE_SLOCKS for your architecture and add the definitions. Otherwise, if you have library-based locks, enable them. The mechanism in `threads.h` is similar.

Once a working engine is achieved, it should be possible to continue with the standard installation procedure, which will try to use a completely static version of the standalone compiler (`ciaoc.sta` in the `ciaoc` directory) to compile the interactive top-level (`ciaosh`) and a new version of the standalone compiler (`ciaoc`). These in turn should be able to compile the Prolog libraries. You may also need to look at some libraries (such as, for example, `sockets`) which contain C code. If you do succeed in porting to a platform that is currently unsupported please send the `mkf-CIAOARCH` and any patches to `ciao@clip.dia.fi.upm.es`, and we will include them (with due credit, of course) in the next distribution.

200.8 Troubleshooting (nasty messages and nifty workarounds)

The following a list of common installation problems reported by users:

- **Problem:** Compilation errors appear when trying a new installation/compilation after the previous one was aborted (e.g., because of errors).

  Possible reason and solution: It is a good idea to clean up any leftovers from the previous compilation using `make engclean` before restarting the installation or compilation process.

- **Problem:**

  During engine compilation, messages such as the following appear: `tasks.c:102:PTHREAD_CANCEL_ASYNCHRONOUS undeclared (first use of this function)`.

  Possible reason and solution:

  Your (Linux?) system does not have (yet) the Posix threads library installed. You can upgrade to one which does have it, or download the library from

  `http://pauillac.inria.fr/~xleroy/linuxthreads/index.html`

  and install it, or disable the use of threads in Linux: for this, edit the `SETTINGS` file and specify `USE_THREADS=no`, which will avoid linking against thread libraries (it will disable the use of thread-related primitives as well). Clean the engine with `make engclean` and restart compilation.

  If you have any alternative threads library available, you can tinker with `engine/threads.h` and the files under `makefile-sysdep` in order to get the task managing macros right for your system. Be sure to link the right library. If you succeed, we (`ciao@clip.dia.fi.upm.es`) will be happy of knowing about what you have done.

- **Problem:**

  `-lpthread: library not found` (or similar)

  Possible reason and solution:

  Your (Linux?) system seems to have Posix threads installed, but there is no threads library in the system. In newer releases (e.g., RedHat 5.0), the Posix threads system calls have been included in `glibc.so`, so specifying `-lpthread` in `makefile-sysdep/mkf-LINUX` is not needed; remove it. `make engclean` and restart installation.

  Alternatively, you may have made a custom installation of Posix threads in a non-standard location: be sure to include the flag `-L/this/is/where/the/posix/libraries/are` **before** `-lpthread`, and to update `/etc/ld.so.conf` (see `man ldconfig`).

- **Problem:**

  `Segmentation Violation` (when starting the first executable)

  Possible reason and solution:

  This has been observed with certain older versions of `gcc` which generated erroneous code under full optimization. The best solution is to upgrade to a newer version of `gcc`. Alternatively, lowering the level of optimization (by editing the `SETTINGS` file in the main directory of the distribution) normally solves the problem, at the cost of reduced execution speed.

- **Problem:** `ciaoc: /home/clip/lib/ciao/ciao-X.Y/engine/ciaoengine: not found`

  Possible reason and solution:

  - The system was not fully installed and the variable `CIAOENGINE` was not set.
  - The system was installed, the variable `CIAOENGINE` is set, but it is does not point to a valid ciaoengine.

  See the file `LIBROOT/ciao/DOTcshrc` for user settings for environment variables.
- **Problem:**

  `ERROR: File library(compiler) not found - aborting...` (or any other library is not found)

  Possible reason and solution:

  - The system was not installed and the variable `CIAOLIB` was not set.
  - The system is installed and the variable `CIAOLIB` is wrong.

  See the file `LIBROOT/ciao/DOTcshrc` for user settings for environment variables.
- **Problem:**

  `ERROR: File <some_directory>/<some_file>.itf not found - aborting...`

  Possible reason and solution:

  Can appear when compiling `.pl` files. The file to compile (<some_file>.pl) is not in the directory <some_directory>. You gave a wrong file name or you are in the wrong directory.
- **Problem:**

  `*ERROR*: /(write_option,1) is not a regular type` (and similar ones)

  Possible reason and solution:

  This is not a problem, but rather the type checker catching some minor inconsistencies which may appear while compiling the libraries. Bug us to remove it, but ignore it for now.
- **Problem:**

  `WARNING: Predicate <some_predicate>/<N> undefined in module <some_module>`

  Possible reason and solution:

  It can appear when the compiler is compiling Ciao library modules. If so, ignore it (we will fix it). If it appears when compiling user programs or modules, you may want to check your program for those undefined predicates.
- **Problem:**

  `gmake[1]: execve: /home/clip/mcarro/ciao-0.7p2/etc/collect_modules: No such file or directory`

  Possible reason and solution:

  Check if collect_modules is in $(SRC)/etc and is executable. If it is not here, your distribution is incorrect: please let us know.
- **Problem:**

  `make: Fatal error in reader: SHARED, line 12: Unexpected end of line seen`

  Possible reason and solution:

  You are using standard Un*x make, not GNU's make implementation (gmake).
- **Problem:**

  `WARNING`s or `ERROR`s while compiling the Ciao libraries during installation.

  Possible reason and solution:

  It is possible that you will see some such errors while compiling the Ciao libraries during installation. This is specially the case if you are installing a Beta or Alpha release of Ciao. These releases (which have "odd" version numbers such as 1.5 or 2.1) are typically snapshots

of the development directories, on which many developers are working simultaneously, which may include libraries which have typically not been tested yet as much as the "official" distributions (those with "even" version numbers such as 1.6 or 2.8). Thus, minor warnings may not have been eliminated yet or even errors can sneak in. These warnings and errors should not affect the overall operation of the system (e.g., if you do not use the affected library).

201 Installing Ciao from a Win32 binary distribution

Author(s): Daniel Cabeza, Manuel Carro, Manuel Hermenegildo.

Version: 1.8#1 (2002/5/27, 19:57:48 CEST)

Version of last change: 1.5#92 (2000/3/28, 17:41:25 CEST)

This describes the installation of Ciao after downloading the Windows *binary* (i.e., *precompiled*) distribution. It includes the installation of libraries and manuals and applies to Windows NT/95/98 systems. This is the simplest Windows installation, since it requires no compilation and is highly recommended. However, it is also possible to compile Ciao from the source distribution on these systems (please refer to Chapter 200 [Installing Ciao from the source distribution], page 735 for details).

If you find any problems during installation, please refer to Section 200.8 [Troubleshooting (nasty messages and nifty workarounds)], page 742. See also Section 202.3 [Downloading new versions], page 749 and Section 202.4 [Reporting bugs], page 750.

201.1 Win32 binary installation summary

Please follow these steps (below we use the terms *folder* and *directory* interchangeably):

1. Download the precompiled distribution and unpack it into any suitable folder, such as, e.g., `C:\Program Files`.

   This will create there a folder whose name reflects the Ciao version. Due to limitations of Windows related to file associations, do not put Ciao too deep in the folder hierarchy. For unpacking you will need a recent version of a zip archive manager – there are many freely available such as `WinZip`, `unzip`, `pkunzip`, etc. (see for example `www.winzip.com`). Some users have reported some problems with version 6.2 of WinZip, but no problems with, e.g., version 7. With WinZip, simply click on "Extract" and select the extraction folder as indicated above.
2. Stop any Ciao-related applications.

   If you have a previous version of Ciao installed, make sure you do not have any Ciao applications (including, e.g., a toplevel shell) running, or the extraction process may not be able to complete. You may also want to delete the entire folder of the previous installation to save space.
3. Open the Ciao source directory created during extraction and run (e.g. by double-clicking on it) the `install(.bat)` script. Answer "yes" to the dialog that pops up and type any character in the installation window to finish the process. You may need to reboot for the changes in the registry to take effect.

   This will update the windows registry (the file `ciao(.reg)` lists the additions) and also create some `.bat` files which may be useful for running Ciao executables from the command line. It also creates initialization scripts for the `emacs` editor. The actions performed by the installation script are reported in the installation window.
4. You may want to add a *windows shortcut* in a convenient place, such as the desktop, to `ciaosh.cpx`, the standard interactive toplevel shell. It is located inside the `shell` folder (e.g., click on the file `ciaosh.cpx` with the right mouse button and select the appropriate option, `Send to->Desktop as shortcut`).
5. You may also want to add another shortcut to the file `ciao(.html)` located inside `doc\reference\ciao_html` so that you can open the Ciao manual by simply double-clicking on this shortcut.
6. Finally, if the (freely available) `emacs` editor/environment is not installed in your system, we *highly recommend* that you also install it at this point. While it is easy to use Ciao with any editor of your choice, the Ciao distribution includes a very powerful *application*

development environment which is based on `emacs` and which enables, e.g., source-level debugging, syntax coloring, context-sensitive on-line help, etc. If you are not convinced, consider that many programmers inside Micros*ft use `emacs` for developing their programs.

The emacs editor (in all its versions: Un*x, Windows, etc.) can be downloaded from, for example, `http://www.emacs.org/`, and also from the many GNU mirror sites worldwide (See `http://www.gnu.org/` for a list), in the `gnu/emacs` and `gnu/windows/emacs` directories. You can find answers to frequently asked questions (FAQ) about `emacs` in general at `http://www.gnu.org/software/emacs/emacs-faq.text` and about the Windows version at `http://www.gnu.org/software/emacs/windows/ntemacs.html` (despite the `ntemacs` name it runs fine also as is on Win9X and Win2000 machines).

You need to tell `emacs` how to load the Ciao mode automatically when editing and how to access the on-line documentation:

- Start `emacs` (double click on the icon or from the `Start` menu). Open (menu `Files->Open File` or simply ⟨^X⟩⟨^F⟩) the file `ForEmacs.txt` that the installation script has created in directory where you installed the Ciao distribution.
- Copy the lines in the file (select with the mouse and then menu `Edit->Copy`). Open/Create using `emacs` (menu `Files->Open File` or simply ⟨^X⟩⟨^F⟩) the file `~/.emacs` (or, if this fails, `c:/.emacs`).
- Paste the two lines (menu `Edit->Paste` or simply ⟨^Y⟩) into the file and save (menu `Files->Save Buffer` or simply ⟨^X⟩⟨^S⟩).
- Exit `emacs` and start it again.

`emacs` should not report any errors (at least related to Ciao) on startup. At this point the `emacs` checks in the following section should work.

201.2 Checking for correct installation on Win32

After the actions and registry changes performed by the installation procedure, you should check that the following should work correctly:

- Ciao-related file types (`.pl` source files, `.cpx` executables, `.itf,.po,.asr` interface files, `.pls` scripts, etc.) should have specific icons associated with them (you can look at the files in the folders in the Ciao distribution to check).
- Double-clicking on the shortcut to `ciaosh(.cpx)` on the desktop should start the typical Prolog top-level shell in a window. If this shortcut has not been created on the desktop, then double-clicking on the `ciaosh(.cpx)` icon inside the `shell` folder within the Ciao source folder should have the same effect.
- In the top-level shell, Prolog library modules should load correctly. Type for example `use_module(library(dec10_io)).` at the Ciao top-level prompt –you should get back a prompt with no errors reported.
- To exit the top level shell, type `halt.` as usual, or ⟨^D⟩.

Also, the following documentation-related actions should work:

- Double-clicking on the shortcut to `ciao(.html)` which appears on the desktop should show the Ciao manual in your default WWW browser. If this shortcut has not been created you can double-click on the `ciao(.html)` file in the `doc\reference\ciao_html` folder inside the Ciao source folder. Make sure you configure your browser to use *style sheets* for correct formatting of the manual (note, however, that some older versions of Explorer did not support style sheets well and will give better results turning them off).
- The `doc\reference` folder contains the manual also in the other formats present in the distribution, such as `info` (very convenient for users of the `emacs` editor/program development system) and `postscript` or `pdf`, which are specially useful for printing. See Section 3.2.7 [Printing manuals (Win32)], page 25 for instructions.

Finally, if `emacs` is installed, after starting it (double-clicking on the `emacs` icon or from the `Start` menu) the following should work:

- Typing ⟨^H⟩ i (or in the menus `Help->Manuals->Browse Manuals with Info`) should open a list of manuals in info format in which the Ciao manual(s) should appear.
- When opening a Prolog file, i.e., a file with `.pl` or `.pls` ending, using ⟨^X⟩⟨^F⟩`filename` (or using the menus) the code should appear highlighted according to syntax (e.g., comments in red), and `Ciao/Prolog` menus should appear in the menu bar on top of the `emacs` window.
- Loading the file using the `Ciao/Prolog` menu (or typing ⟨^C⟩ l) should start in another emacs buffer the Ciao toplevel shell and load the file. You should now be able to switch the the toplevel shell and make queries from within `emacs`.

Note: when using `emacs` it is *very convenient* to swap the locations of the (normally not very useful) ⟨Caps Lock⟩ key and the (very useful in `emacs`) ⟨Ctrl⟩ key on the keyboard. How to do this is explained in the `emacs` frequently asked questions FAQs (see the `emacs` download instructions for their location).

If you find that everything works but `emacs` cannot start the Ciao toplevel you may want to check if you can open a normal Windows shell within `emacs` (just do ⟨M-x⟩ `shell`). If you cannot, it is possible that you are using some anti-virus software which is causing problems. See `http://www.gnu.org/software/emacs/windows/faq3.html#anti-virus for a` workaround.

In some Windows versions it is possible that you had to change the *first* backslashes in the DOTemacs.el file in the Ciao Directory. E.g., assuming you have installed in drive `c:`, instances of `c:\` need to be changed to `c:/`. For example: `c:\prolog/ciao-1.7p30Win32/shell/ciaosh.bat` should be changed to `c:/prolog/ciao-1.7p30Win32/shell/ciaosh.bat`.

201.3 Compiling the miscellaneous utilities under Windows

The `etc` folder contains a number of utilities, documented in the manual in *PART V - Miscellaneous Standalone Utilities*. In the Win32 distribution these utilities are not compiled by the installation process. You can create the executable for each of them when needed by compiling the corresponding `.pl` file.

201.4 Server installation under Windows

If you would like to install Ciao on a server machine, used by several clients, the following steps are recommended:

- Follow the standard installation procedure on the server. When selecting the folder in which Ciao is installed make sure you select a folder that is visible by the client machines. Also make sure that the functionality specified in the previous sections is now available on the server.
- Perform a *client installation* on each client, by running (e.g., double-click on it) the `client.bat` script. This should update the registry of each client. At this point all the functionality should also be available on the clients.

201.5 CGI execution under IIS

The standard installation procedure updates the windows registry so that Ciao executables (ending in `.cpx`) are directly executable as CGIs under Microsoft's IIS. In the event you reinstall IIS, you probably would lose the entries in the registry which allows this. In that case, processing the file `ciao.reg` produced during the installation (or simply reinstalling Ciao) will add again those entries.

201.6 Uninstallation under Windows

To uninstall Ciao under Windows, simply delete the directory in which you put the Ciao distribution. If you also want to delete the registry entries created by the Ciao installation (not strictly needed) this must currently be done by hand. The installation leaves a list of these entries in the file `ciao.reg` to aid in this task. Also, all the register entries contain the word *ciao*. Thus, to delete all Ciao entries, run the application `regedit` (for example, by selecting `Run` from the Windows `Start` menu), search (⟨F⟩) for *ciao* in all registry entries (i.e., select all of `Keys`, `Values`, and `Data` in the `Edit->Find` dialog), and delete each matching key (click on the left window to find the matching key for each entry found).

202 Beyond installation

Author(s): Manuel Carro, Daniel Cabeza, Manuel Hermenegildo.
Version: 1.8#1 (2002/5/27, 19:57:48 CEST)
Version of last change: 1.7#55 (2001/1/26, 17:36:30 CET)

202.1 Architecture-specific notes and limitations

Ciao makes use of advanced characteristics of modern architectures and operating systems such as multithreading, shared memory, sockets, locks, dynamic load libraries, etc., some of which are sometimes not present in a given system and others may be implemented in very different ways across the different systems. As a result, currently not all Ciao features are available in all supported operating systems. Sometimes this is because not all the required features are present in all the OS flavors supported and sometimes because we simply have not had the time to port them yet.

The current state of matters is as follows:

Mac OS X (Darwin):
: multithreading, shared DB access, and locking working.

LINUX: multithreading, shared DB access, and locking working.

Solaris: multithreading, shared DB access, and locking working.

IRIX: multithreading, shared DB access, and locking working.

SunOS 4: multithreading, shared DB access, and locking NOT working.

Win 95/98/NT/2000:
: multithreading, shared DB access, and locking working. Dynamic linking of object code (C) libraries NOT working.

The features that do not work are disabled at compile time.

202.2 Keeping up to date with the Ciao users mailing list

We recommend that you join the Ciao *users mailing list* (`ciao-users@clip.dia.fi.upm.es`), in order to receive information on new versions and solutions to problems. Simply send a message to `ciao-users-request@clip.dia.fi.upm.es`, containing in the body only the word:

```
subscribe
```

alone in one line. Messages in the list are strictly limited to issues directly related to Ciao Prolog and your email address will of course be kept strictly confidential. You mail also want to subscribe to the `comp.lang.prolog` newsgroup.

There is additional info available on the Ciao system, other CLIP group software, publications on the technology underlying these systems, etc. in the CLIP group's WWW site `http://clip.dia.fi.upm.es`.

202.3 Downloading new versions

Ciao and its related libraries and utilities are under constant improvement, so you should make sure that you have the latest versions of the different components, which can be dowloaded from:

```
http://clip.dia.fi.upm.es/Software
```

202.4 Reporting bugs

If you still have problems after downloading the latest version and reading the installation instructions you can send a message to `ciao-bug@clip.dia.fi.upm.es`. Please be as informative as possible in your messages, so that we can reproduce the bug.

- For *installation problems* we typically need to have the version and patch number of the Ciao package (e.g., the name of the file downloaded), the output produced by the installation process (you can capture it by redirecting the output into a file or cutting and pasting with the mouse), and the exact version of the Operating System you are using (as well as the C compiler, if you took a source distribution).
- For *problems during use* we also need the Ciao and OS versions and a small example of code which we can run to reproduce the bug.

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